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N.A.39

WHEN the chairman of Blackburn and General Aircraft, Ltd., claimed the other day that the "security-cloaked" aircraft now being built by his company was ahead of anything in its class in the world, he expressed the belief that it would go into widespread service at home and abroad. We, on our own part, surmised that he was alluding to the new pure-jet carrier-based strike aircraft ordered for the Royal Navy in replacement of the Wyvern. Any lingering doubt was obligingly removed by the "security-cleared" Select Committee Report on the supply of military aircraft (*Flight* last week) where reference was made to a Blackburn-built supersonic naval strike machine, said to be "really a bomber" and known as the N.A.39. So deeply embedded in verbiage was this nugget of intelligence that we were able to prise it out only after a day's hard digging at the 300-odd-page report—and we now stake our modest claim to be the only journal which succeeded in doing so.

The characteristics of the N.A.39 can only be guessed at; but any guessing game is more exciting if there is a clue, and as a clue we are entitled to consider Blackburn's Farnborough-displayed model of a naval aircraft (no doubt hypothetical) having two flank-mounted jets. If we add to this the probability that any supersonic naval "bomber" is likely to have two engines, we may reasonably substitute "twin-jet" for "pure-jet" in our specification.

The "discovery" of the new Blackburn proved a timely one, for carrier-borne machines of its class are much in the public mind—the Commander of the U.S. Sixth Fleet having intimated that Douglas Skywarriors, shortly to join his carriers, could make atomic attacks on Moscow from their mobile Mediterranean bases. New as the Skywarrior is, its supersonic replacement, the North American A3J, is already on order to the tune of 86 million dollars. Positively known to have two jets, this will be a two-seater, capable of more than 1,000 m.p.h.; so if the Blackburn claim is made good, the N.A.39 will be a very remarkable aeroplane.

Presumably because no Canberra replacement is known to be on order for the R.A.F., the suggestion has been advanced that the new Blackburn might find a shore-based application also. And well it might, though its prospects in this direction may have been diminished by the recent cancellation of the Martin XB-68 supersonic tactical bomber for the U.S.A.F. This drastic move has been related to President Eisenhower's budget message that the U.S. Army's growing missile capability is decreasing its dependence on the U.S.A.F. for the close support of troops. The possibility still remains that the U.S.A.F. may yet have another manned tactical bomber, though of a type which would fill an alternative rôle as a long-range intercepter.

However the supersonic bomber pattern may shape, we may be reassured that in the N.A.39 the Royal Navy is promised a supersonic bomber of the highest capability.

Straight, Steel Wings

THE Select Committee Report was also the source of our disclosure of a British project for an all-steel supersonic research aircraft with straight, thin wings. Here again a little guessing game may prove edifying. We can take our first clue from our own pages of June 8 last, wherein it was remarked that a British supersonic bomber might follow the pattern of a model displayed by Sir Arnold Hall on the occasion of the R.A.E. Jubilee. This model had small, straight wings carrying jet pods at their tips, and we remarked that a long-range bomber of the type might require two, three or more turbojets in each wing-tip housing. Clue number two is Sir Roy Dobson's recent remark that the Vulcan will probably be the last of the subsonic bombers and that "in the future we shall be entering realms that none of us knows everything about."

Could the new machine be a test vehicle for a supersonic Avro bomber and/or the "coalition" airliner proclaimed in this issue.

FROM ALL QUARTERS

Supersonic Coalition

ON Friday of last week, the Ministry of Supply issued the following statement: "The Ministry of Supply, in conjunction with the aircraft industry and the national airline corporations, have embarked on a research project with a view to the possible development of a supersonic airliner. Details of the project are not at present being disclosed." The aircraft firms were later named as A. V. Roe, Bristol, de Havilland, Handley Page, Rolls-Royce, Short Bros. and Harland, and Vickers-Armstrongs.

It is no secret that for the past year or more each of the British firms listed above, as well as others, have had small teams engaged on initial project work on supersonic airliner designs. The possibility that all these firms will co-ordinate their design and research work would seem, at the moment, to be remote; but it may have been brought nearer by the multilateral discussions with the M.o.S. There are as many conflicting ideas on supersonic transport as there are firms who are studying the problem.

If it is decided that the British industry's next big step in the commercial field is the supersonic airliner, then the M.o.S. needs to be quite clear about the technical problems involved, and how the necessarily heavy Government financing shall be directed. These, presumably, are the objects of the present talks.

Reports earlier this week that the Government has "scrapped" its plans for the subsonic D.H.118 received neither confirmation nor denial. But, in the light of the news recorded above, they seem likely to prove true.

New Defence Policy

THE appointment of Mr. Duncan Sandys as Minister of Defence, with exceptional powers, is of particular interest to the aviation world because of his previous connections with it as Minister of Supply (1951-54), chairman of the War Cabinet Committee for defence against German "V" weapons (1943-45) and Parliamentary Secretary, Ministry of Supply (1943-44).

The powers vested in Mr. Sandys as Defence Minister were defined by the Prime Minister in the House of Commons on January 24. He will be responsible for defence policy and for the administration and efficiency of the armed forces. He has been entrusted with formulating a policy which will secure a substantial reduction in expenditure and manpower; and it will be his job to prepare a plan for "reshaping and reorganizing the armed forces." All decisions on matters of policy affecting the size, shape and disposition of the armed forces, their equipment and supply (including defence research and development), their pay and conditions of service, will be the new Minister's responsibility.

Mr. Sandys is to have directly responsible to him, as his own Chief of Staff, Marshal of the Royal Air Force Sir William Dickson. The latter will continue as Chairman of the Chiefs of Staffs Committee and is the senior officer on the Defence Ministry's military staff.

The new Minister arrived in Washington last Sunday for talks with his opposite number, U.S. Defence Secretary Mr. Charles Wilson. One of their subjects for discussion was said to be missile production in both countries.

Mr. Duncan Sandys, the new Minister of Defence, and Marshal of the Royal Air Force Sir William Dickson. (See news item below.)

Exports Exceed £100m

AS was expected when one record month succeeded another last year, British aviation exports for 1956 proved to be the highest ever, exceeding £100m for the first time. The December figure, £7,115,739, brought the total for the year to £104,460,562, an increase of 58 per cent over the previous record total in 1955.

Aeroplanes and parts ("excluding engines, electrical parts and appliances") accounted for £71,759,067 of last year's foreign sales, this figure alone being far in excess of the total aviation exports in any previous year. The United States (£17.2m worth) was Britain's best customer; next came Australia (almost £11m) and Sweden (£7.8m).

Sales of engines abroad last year amounted to £27,902,808, compared with £22.2m in 1955. Electrical equipment totalled £2,682,209 (an increase of over 20 per cent), instruments £1,428,657 and tyres £687,821.

Sir Ivan Holyman

WE record with great regret the death in Honolulu on January 20 of Sir Ivan Holyman, chairman and managing director of Australian National Airways. Sir Ivan, who was 60, was born and educated in Australia, and served with the Australian Forces as a captain during the first world war. Afterwards he returned to the family firm of William Holyman and Sons Pty., Ltd., and in 1932 formed Holyman Bros. Pty., Ltd., an air transport firm which started operations by flying a D.H. Fox Moth between Launceston and Flinders Island, Bass Straight. A subsequent amalgamation with a competitor, Mr. L. McK. Johnson—who flew a Desoutter monoplane—led to the formation of Tasman Aerial Services, and flights between Launceston and Melbourne with a D.H.84 Dragon.

Sir Ivan Holyman

Australian National Airways was formed in 1936 through the amalgamation of Holman Airways Pty., Ltd. (as Tasman Aerial Services became when Johnson was bought out) and other companies. Sir Ivan then introduced into Australia the DC-2 and such innovations as air hostesses, free flight meals, automatic insurance, and the transport of bulk freight and livestock. He was created a K.B.E. in 1956 for services to Australian aviation.

Miles Student Nears Completion

WITHIN the next few weeks the Miles M.100 Student, the prototype of which is rapidly nearing completion at Shoreham airport, should make its first flight. The makers state that, for a production batch of 200, each aircraft would cost the remarkably small sum of £13,000, including engine. This, it is claimed, is half the cost of Britain's only other basic jet trainer; and the Student would use only half as much fuel. With 500 Students flying 500 hours a year each, this would result in a fuel saving of 12½ million gallons.

R.Ae.C. Annual Awards

BOTH the 1956 Britannia Trophy and the Geoffrey de Havilland Trophy have been awarded to Mr. Peter Twiss, in recognition of his world speed record of 1,132 m.p.h. in the Fairey F.D.2 on March 10 last year. This was announced last week by the committee of the Royal Aero Club. Mr. Twiss was awarded the Britannia Trophy for being the first man to be officially timed, in accordance with F.A.I. regulations, to fly at over 1,000 m.p.h., and the Geoffrey de Havilland Trophy for the record speed itself.

***STANDING DOWN:** A cocktail party in the conference room at London Airport on January 23 marked the retirement of the Airport Commandant, Sir John D'Albiac. Sir John is seen with Lady D'Albiac and with one of the gifts—a portable typewriter—donated by colleagues.*

***SKI-SHOD:** The first ski-equipped Lockheed C-130A. For a close-up view of one of the skis see "Flight" of January 11.*

Lt-Cdr. G. A. J. Goodhart, R.N., receives the Royal Aero Club Silver Medal for his world gliding record over a 300 km triangular course in Australia on January 7 last year. He reached a speed of 46·52 m.p.h. over the course, beating the previous record of 24·56 m.p.h. by "an unprecedented margin."

R.Ae.C. Silver Medals also go to Cdr. H. C. N. Goodhart, R.N., and Mr. Frank Foster for winning the world two-seater gliding championship at St. Yan last July; and Mr. R. Gibbs gets a Bronze Medal as world model aircraft speed champion and holder of the Class I and II world speed records for model aircraft.

M.T.C.A. Changes

APPOINTED to succeed Mr. John Profumo as Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation is Mr. Airey Neave. Mr. Profumo, who has gone to the Colonial Office, has held this position with the M.T.C.A. since 1952.

Mr. Neave, who was formerly Parliamentary Private Secretary to the Secretary of State for the Colonies, is a barrister and Member of Parliament for Abingdon, Berkshire. He served with great distinction during the war and was later a member of the British War Crimes Executive.

Mr. George Nugent has taken over from Mr. Hugh Molson as the other Joint Parliamentary Secretary to the M.T.C.A., for inland transport.

Both junior Ministers continue to be responsible to Mr. Harold Watkinson, who was appointed Minister of Transport and Civil Aviation in 1955, but was elevated to Cabinet rank in the new Government.

Brazil's V.I.P. Viscount

LAST week Field Aircraft Services, Ltd., demonstrated the Viscount which they have just converted to V.I.P. standard for the President of the United States of Brazil. The machine is the 150th Viscount and was originally ordered by Braathen's S.A.F.E. It now contains a superbly finished private writing-room and sleeping quarters aft (photograph, p. 157), a 22-seat passenger cabin forward and a separate radio operator's compartment.

Extra radio equipment includes Loran, M.F. and H.F., and Fields have also fitted a Kelvin and Hughes periscopic sextant in a specially prepared cabin roof mounting. A second Brazilian V.I.P. machine, a Viscount 764D, will be delivered direct from Vickers to Fields to be fitted with an even more luxurious interior.

Field Aircraft Services, Ltd., now have considerable experience of Viscounts. They have manufactured sub-assemblies, developed the ingenious pictorial maintenance chart for overhauls and have now built a complete fuselage mock-up to facilitate the design of V.I.P. interiors. The company is experimenting with some new materials for this purpose, and some of the bulkheads in the first Brazilian V.I.P. Viscount are made of Sapele mahogany veneer on expanded p.v.c. foam. All the work on this aircraft was done at the company's repair, modification and conversion factory at Tollerton, Notts.

Recognition Contest Results

DETAILED results of the Aircraft Recognition Society's all-England recognition contest, held on January 19, are given below. The winners of the Hurricane Trophy, Post 2/Q3 (Wallington), Royal Observer Corps, were successful for the second year running and for the fourth time in six successive contests. A total of 176 entrants competed.

Hurricane Trophy (highest score regardless of category).—Post 2/Q3 (Wallington), R.O.C.: M. J. Hooks, 34 points; M. N. Jamieson, 30; J. W. Ware, 30. Total, 94. *Runners-up.*—Registration Research: T. Pharo, 35; J. Buer, 29; M. Stroud, 24. Total, 88.

Heracles Trophy (leading team of A.T.C. or C.C.F. entrants).—No. 2236 (Stanmore) Sqn., A.T.C.: A. R. Wigmore, 29; J. Dunn, 25; C. Mann, 22. Total, 76. *Runners-up.*—No. 4/F (Ilford) Sqn., A.T.C.: R. N. Slater, 25; R. Dann, 25; R. E. Holmes, 25. Total, 75.

B.E.A. Viscount Trophy (leading Service team).—Royal Netherlands Air Force: J. Valette, 27; K. R. de Graaf, 26; A. F. Corneth, 25. Total, 78. *Runners-up.*—No. 1 School of Technical Training, Halton: D. J. Parker, 28; A. B. R. Curd, 24; D. P. Brown, 21. Total, 73.

"Air Pictorial" Trophy (highest individual score).—T. Pharo, 35 (this is only the second time in ten years that a competitor has gained full marks). *Runner-up:* M. J. Hooks, 34.

SPOTLIGHT ON THE INDUSTRY

IN reviewing last week the Select Committee report on the supply of military aircraft, we observed that many points of interest were cited in evidence.

A. CDRE. H. J. KIRKPATRICK, of the Air Ministry, remarked, for instance, that there had been an increasing desire to get the Central Fighter Establishment in on the early trials of new types —"somewhere perhaps about the third prototype." Indeed, he said, C.F.E. had already "had a look" at the F.23 [English Electric P.1]. It was hoped that the C.F.E. would have some F.23s for tactical trials before a release to the Service.

SIR ARNOLD HALL remarked that the Hunter was designed for two 30 mm guns firing a particular type of ammunition, and that it was now carrying four of the guns, using very much more formidable ammunition. In other words, it was "carrying a kick" a good deal more than twice that for which it was conceived.

MR. W. E. W. PETTER described the history of the Gnat. "I was looking," he said, "for a product for a fairly small firm with not unlimited resources, with a factory that was good at mass-producing small components, and I was also looking for something which would not automatically be killed by competition for existing types or by much larger firms. I got the idea of the light fighter when the Tu-4 threat was serious in 1951 from an Air Force officer. The idea caught on well with the Air Ministry to start with; 24 were ordered by the C.A.S. of the day in 1951, or, at any rate, he asked for them. These were approved by the D.R.P.C. [Defence Research Policy Committee] about October 1951, but due to the Ministry of Supply not altogether believing in this concept the machinery was never really put in motion to make these 24 machines. For one thing, the engine I wanted [the Saturn] was in a very early state at Bristol and thought to be too far off to fit in the time scale the Air Staff had in mind. The Air Staff were asked to re-write the specification for a longer-term project; they tried for a long time and did not succeed in making anything that was really more than an indifferent Hunter. The result was that the M.o.S. dropped the whole thing in 1952; the engine was stopped; and we went on as a private venture. . . .

"It was only when NATO got interested in the concept that the engine was started again in 1953. . . . Unfortunately the specification was very different from what the British Air Staff would think suitable . . . it became more and more a ground attack fighter. I am sure the British Air Staff are right: you have to have a good fighter and after that carry out the external things which make it a ground attack scheme. As a result of that, and lack of support from home, we were not placed in the competition and the French and Italians are going on with American money. . . . It now looks as if we have a very valuable

[*Contd. overleaf*

"FLIGHT" AND THE BRITANNIA

IN publishing the special articles in the "Britannia" section of this enlarged issue, "Flight" does not seek to describe the aircraft itself; that we have done already, as is shown below. Our purpose this week is fittingly to salute the entry of an exceptionally fine British aircraft into commercial service; and we do so chiefly by reviewing and explaining the immense amount of painstaking work which the Bristol Company and its suppliers of special equipment have put into the development of the Britannia for its world wide duties. In this task they have received the closest co-operation from the first users, B.O.A.C., two of whose pilots contribute to this issue vivid and absorbing articles on their flying experiences with the new aircraft.

For readers who wish to refer back to the more purely structural and technical background, the following list of relevant issues of "Flight" will be of use:—

Airframe and Complete Aircraft:—Full descriptions: Aug. 22, 1952; Aug. 12, 1955. Major progress reports: Jan. 25, 1952; Feb. 29, 1952; Mar. 7, 1952; Aug. 8, 1952; Feb. 6, 1953; Jan. 1, 1954; Aug. 13, 1954; Oct. 15, 1954; Jan. 21, 1955; Apr. 22, 1955; Nov. 11, 1955; Jan. 6, 1956; Mar. 30, 1956.

Proteus Engines:—Full description: June 6, 1952. Reports: Aug. 12, 1955; Sept. 9, 1955.

Orion Engine.—Full description: Oct. 28, 1956.

SPOTLIGHT ON THE INDUSTRY . . .

export product. . . . Countries such as India, Finland and Switzerland cannot afford anything else, and will be able to defend themselves, whereas they could not do anything at all if they were trying to use the latest American or British machines. As far as the Air Force is concerned the interest in the two-seater trainer version of the Gnat is important. . . ."

Mr. Petter gave two examples of how time might have been saved in development. One example, was the bombing up of the Canberra. Mr. Petter said, "They [the M.o.S.] designed and had made bombing trolleys. . . . These were not altogether satisfactory and a new approach had to be made to the problem when the Canberra went into service. I think if the firm had been given the duty of bombing up they would have had something satisfactory by the time the Canberra entered service. Some of the equipment was late in coming forward—the bombing equipment, the radar—and I had considerable doubts about it in the design stages. I think what was ultimately done was to throw out much of the elaborate black boxes and put back war-time equipment and improve it. It could have been done earlier, and to that extent the Canberra would have reached the Service in a more useful condition."

An occasional touch of humour lightened the necessarily ponderous proceedings, as when one member of the Committee remarked that it would be "very uncomfortable to have Valiants running out of one's ears." SIR FREDERICK HANDLEY PAGE made his own contribution when asked if he was not bothered by a great number of modifications. "Everybody is," said Sir Frederick, and went on, "I was once walking in the streets of Milan with Caproni. . . . He was a big aircraft manufacturer, a little tiny man about so high. He was walking along beside me and I mentioned the word modifications. He looked up at me in surprise and said, 'You have modifications too in your country?' "

LORD HIVES' evidence was characteristic. He recalled the occasion when Rolls-Royce said to the M.o.S. "We want an engine to replace the Dart." Lord Hives continued: "The Ministry came back and said, 'We have got an engine to replace the Dart; we have got an Eland,' and we said, 'That is just too bad: it is not a Rolls-Royce engine. We say, in our interests, to look after our business, we have got to make one of those engines, whether you pay for it or not.' Then we came up against the point and we said, 'You will have to pay a charge on that.' They said, 'We are not going to pay anything,' and we said, 'Yes, you are, that is our terms of business.' A compromise was arrived at because B.E.A., which is a national airline, you see, has specified this engine. I think we are going fifty-fifty on it."

MR. L. J. DUNNETT (M.o.S.) remarked that Mr. Petter's statement about the Gnat was perfectly accurate as far as it went, but that it may have created a somewhat false impression. It was perfectly true, he said, that in 1951 the V.C.A.S. said he would like to see the M.o.S. order and pay for 24 aircraft. "This," he said, "was not the Air Ministry saying: 'We want 24 aircraft and we will pay for them.' This was the Air Ministry saying to the Ministry of Supply: 'Will you as part of your research activities please order 24 aeroplanes, evaluate them and see if they are nice. When you have done that we the Air Ministry will see if we will order any.' " He went on: "It went to the D.R.P.C. on that basis, and I want to say frankly our procedure for dealing with D.R.P.C. business has been evolving and I think it is now better than it was, in that I attend D.R.P.C. meetings in order to give them some idea of what the money position is. In the days when the D.R.P.C. used to look at it purely from the technical point of view all they said on this was: 'We see no reason why the M.o.S., if it has got the money, should not order 24 of these aircraft.' When it came to the M.o.S. the whole thing had to be considered from the financial point of view, and, in fact, on October 16, 1951, we had a letter from Rolls-Royce. Now Mr. Petter at this stage had been designing his aeroplane round an expendable engine which Rolls-Royce had been talking about. . . . In October 1951 Lord Hives wrote to the Controller of Aircraft and said Rolls-Royce would not go ahead with this expendable engine. He said: 'The position about this engine is becoming complicated and mixed up with the Petter fighter project. We are becoming involved in two entirely different engines. This was never the intention and I desire to clarify the position immediately. It is necessary to go back to the origin of this engine as an expendable unit.' . . . He explained that Rolls-Royce was thinking of it as an expendable engine for guided weapons and it was now turning into something which was not an expendable engine. He went on: 'At this point in time we were wrong in not being firm that our investigations had been confined to an expendable engine. We have been carrying out obligations on fighters with various marks of Avon. We just have not the capacity or manpower to dabble with another engine. I admit we have encouraged the Air Staff and Mr. Petter to believe we could do such an engine. We cannot. . . .'

"When the engine disappeared the whole project had to be looked at again. It changed the attitude of the Air Staff, the M.o.S. had no money, nor were we asked to spend millions on developing an engine specially for Mr. Petter's fighter. Mr. Petter said he would make do by putting into his fighter an engine which had been developed for quite other purposes and which did not really have the power to give the aircraft the performance which interested the Air Staff. So although Mr. Petter still believed in his project, it had become very much less attractive to the Air Staff than it would have been with the Rolls-Royce engine. It came back into the picture two years later when the Bristol company had ideas of a light-weight engine, now the Orpheus."

Above, the Folland Gnat. "As far as the Air Force is concerned, the interest in the two-seater trainer version is important" (Mr. W. E. W. Petter).

The English Electric P.1, referred to in the report as the F.23. It is hoped that the Central Fighter Establishment will have some of these machines for tactical trials before they are released to the Service.

Dr. Touch's Report on the Vulcan Accident

ON Thursday of last week the second report* on the Vulcan accident at London Airport on October 1 last year was published. It dealt with the investigation of the accident by Dr. A. G. Touch, Director of Electronics, Research and Development (Ground), M.o.S.—an investigation requested on October 26 by the Minister of Transport and Civil Aviation. Dr. Touch's terms of reference were "to consider whether [at the time of the accident] there was any failure to operate correctly the [G.C.A.] at London Airport and, if so, to consider in what respects and whether, in the light of the circumstances of the accident, any changes are desirable . . ." He conducted his inquiry informally as a private investigation under Accident Regulations, and was not able to use evidence given at the R.A.F. Court of Inquiry.

"An approach under bad weather conditions," says Dr. Touch in his introductory paragraphs, "is a difficult flight operation; in my opinion, far more difficult than is normally recognized. Whatever aid is being used, whatever 'coupler' is employed in the aircraft to interpret the information gleaned and translate it into aircraft motion, the process can be likened to a servo-loop. . . .

". . . the only certain fact we know is that the loop as a whole failed. It will be seen later on that the real issue in this accident is which portion or portions contributed, and some of the main evidence suggesting that the G.C.A. rectangle was at fault concerns the improbability of the aircraft having carried out the flight path as given by the G.C.A. record . . ."

After remarking that "R/T. communications throughout were very good," Dr. Touch goes on to say: "The Vulcan first touched the ground 1,988ft from the runway threshold, 250ft north of the extended centre line, while still under G.C.A. assistance. At impact the aircraft was in a normal approach attitude, with nose up. The rate of descent was not excessive and probably was of the same order as for a normal landing, viz., about 180ft/min. The airspeed was 140 to 145 knots . . .

"The official weather conditions . . . were: wind calm, heavy rain, visibility 1,100 yd, scattered low cloud down to 300ft (2/8), and 7/8th cloud at 700ft. However, conditions were patchy. At the time of the accident there was mist and slight drizzle in the region of the runway threshold. Horizontal visibility looking outwards along the centre line was about 800 yd . . .

"Further back along the approach path, at approximately 1½ n.m. from touch-down, horizontal visibility at ground level was around 200 yd, but the aircraft was seen at a distance of about 400 yd. In this area it does not appear to have been raining heavily . . ."

Answering the question "Did the G.C.A. equipment function properly?" Dr. Touch describes examinations made immediately after the accident and says: "It can be concluded with confidence that errors in setting up the displays, incorrect calibrations, or malfunctioning of any part of the equipment did not occur."

Talk-down Evidence Examined

He then goes on to examine the possibility of "unusual effects" such as radar "ghost" echoes due to the Vulcan's characteristic plan-form, but, in general, dismisses these considerations. The next section of his report reviews in considerable detail the evidence provided by the G.C.A. record, eye-witnesses, the pilot and co-pilot, the controller and the tracker (a woman air traffic control assistant with experience of some 2,000 G.C.A. approaches). After examining and dismissing various explanations suggested by consideration of this mass of material, Dr. Touch makes this statement: "The simpler solution is that the tracker followed the aircraft echo more or less accurately, but that the controller did not pay sufficient attention to the error-meter after the point '80ft. high.'

"It can be seen from the transcript at the talk-down that after this point, the controller's patter was concerned with range and corrections in azimuth. This shows that he was mainly looking at the azimuth display. It is generally recognized that it is difficult to watch both error-meter and display at the same time.

"On this basis, it is possible to formulate a theory which appears to be a reasonable compromise with the evidence. After '100ft. low' (100530)† to 'on the glide-path' (100541½) the rate of descent appears to have been low, of the order of 150ft/min, and this was noticed by eye-witnesses. Afterwards to 100551 it appears to have increased to at least 300ft/min. It is therefore possible that the tracker may have erred slightly on the high side in bisecting the echo. If the latter limit for the time of impact, 100601, is taken, the tolerances given . . . [here an earlier reference is quoted] . . . are possible, and the resulting rate of descent, although high, is acceptable. During the descent, it is not unreasonable to postulate that the tracker lagged behind by 50ft, especially if a fairly large echo was being used. The error-meter would have reached zero about 5 to 6 sec prior to impact and the warning light would have come on about 2 sec before impact. If the tracker switched her light off when she lost the echo just after half a mile, it means postulating that the controller did not observe the meter for a period of 7 to 8 sec. This is not unreasonable, as he was busy with azimuthal corrections and his last two elevation messages had been spaced 10 sec apart. If he glanced at the meter during the first 5 sec he would be left with the impression that the aircraft was returning to the glide-path. The warning light came on too late to be of any value. . . ."

In the next section of his report, headed "Discussion," the investigator makes, *inter alia*, the following observations:—

"I am unable to postulate a really satisfactory theory that would place the aircraft at a lower altitude than that given by the controller near the finish of the approach, to allow for a less steep descent prior to impact. But if any such explanation could be given, it follows that the aircraft must have lost that height elsewhere during the approach . . .

"I therefore accept the G.C.A. record as being correct, subject to the normal tracking, observational and timing errors. In elevation, it is typical of a servo-mechanism out of control. It follows that I accept the existence of a steep dive after the point '80ft high,' since it provides the only rational explanation . . . I have been able to find . . .

"The aircraft crossed the centre line roughly at 4½ miles and was always north of it, in spite of three 5-deg corrections. As a result the controller gave much more attention to azimuth than is normal, and this left him less time for giving elevation and range information.

"Although the controller did not consider that he was under stress, at least he was being hurried more than he thought. A small sample of talk-downs by other controllers chosen at random show a spread in words spoken per minute of 82 to 126, with an average of 110. On this occasion, the controller averaged 146, obviously reacting to the increased ground speed . . .

"Legally, the pilot was entitled to receive enough height information by which to fly his aircraft safely and on which to base his decisions. This he did not get. On the other hand, if the flight-path previous to the '80ft high' point is not taken into account, the time interval of the critical phase is so short that no one could blame the controller for not passing further height data. The issue is, therefore, was the last steep descent unexpected, or could it have been foreseen from the previous flight path so clearly that the controller should have concentrated upon the elevation situation? I find this question exceedingly difficult to answer, but on balance . . . I think the verdict should be that the circumstances were such that it should be classed as a true accident and that the controller was not to blame.

"I must conclude that the talk-down in elevation was poor and, because of its negative character, contributed towards creating the final critical stage. The controller is only responsible for passing instructions and information; he is not in control of the aircraft. The ultimate responsibility for the safety of the aircraft and for the decision whether it is safe to descend below the break-off height, rests with the pilot. Consequently, even if the talk-down was poor, it was subject to the overriding judgment of the pilot, and the controller cannot be blamed for subsequent events arising from the poor control . . ."

Dr. Touch's conclusions and recommendations are as follows. We quote them almost in full:—

Conclusions

"(1) The G.C.A. equipment was correctly set up and calibrated, there is no evidence of malfunctioning or failure.

"(2) The controller failed to warn the pilot of his closeness to the ground.

"(3) During the last 10 sec of the approach the aircraft made a steep descent to ground.

"(4) The cause for this descent was probably due to the build-up of oscillations about the glide-path. Poor 'talk-down' by the controller contributed to this, but as the approach was subject to the overriding judgment of the pilot, the controller was not to blame for events arising from the control.

"(5) The critical phase was the first 4 sec after the descent steepened, during which no height guidance was given to the pilot . . . in view of all the circumstances, I do not think the controller should be blamed.

"(6) No warning was given during the final 5 or 6 sec. It should have been, although it would have been too late. Although it cannot be definitely proved, the most likely theory is that the controller made an error of judgment, concentrating too much upon azimuthal corrections, and paying insufficient attention to the elevation error meter.

"(7) Human errors are more likely to occur under stress . . . In my opinion, evidence exists to show that all the elements in the G.C.A. servo-chain were strained."

Recommendations

"(1) . . . military aircraft of advanced design should not normally be allowed to land at civil airports under bad weather conditions, unless the break-off height is very conservative.

"(2) The record of G.C.A. at London Airport is very good, and the system as at present used does not require any radical change. As aircraft speeds increase, however, the controllers will have less time in which to pass instructions. Unnecessary words, such as 'you are . . .' 'just,' 'quite' and repetitions in the patter should be avoided . . .

"(3) Visual guidance in azimuth and range is adequate almost as soon as contact is made with the approach lighting pattern, but is not adequate in elevation until quite a low altitude is reached. Height data from G.C.A. should therefore be given to as low a height as possible. Danger of undershoots can be reduced, possibly at the expense of a slight increase in overshoots, by concentrating on elevation data during the last stages of the approach. Serious consideration should be given to a procedure in which elevation data only is provided after the pilot has gone visual, or after the break-off height.

"(4) Split responsibilities should be avoided, if possible. A G.C.A. system in which the controller observes both sets of displays, eliminating the need for a tracker, is to be preferred . . .

"(5) If G.C.A. is to continue as a primary approach aid (as distinct from a monitor) it is recommended that photographic recording of the displays should be carried out in addition to recording the talk-down . . ."

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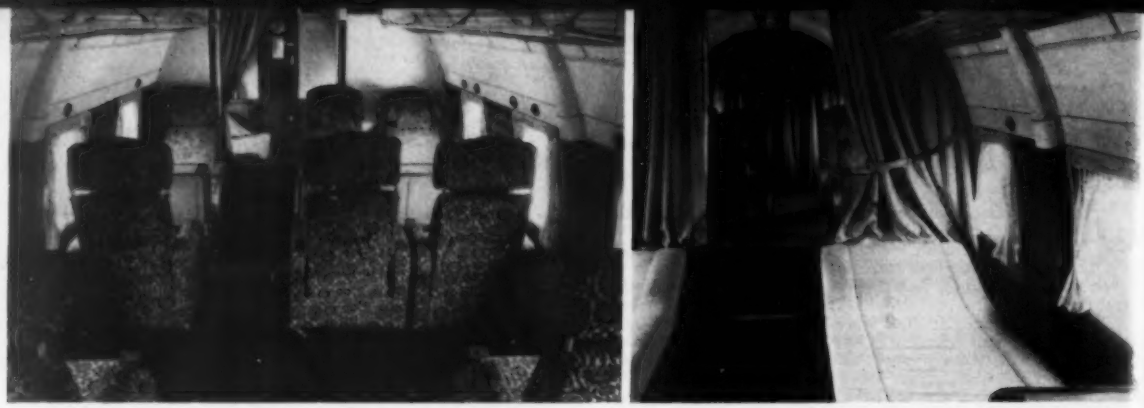
* *Ministry of Transport and Civil Aviation, C.A.P. 143—"Report of the Special Investigation by Dr. A. G. Touch into Certain Aspects of the Accident to the R.A.F. Vulcan Aircraft B.1 XA897 at London Airport on 1st October, 1956. H.M.S.O., price 3s 6d.*

†*This is an expression of time, i.e., 10 hr 05 min 30 sec.—Ed.*



EXECUTIVE FOR A DAY: This striking interior—which included special curtaining and beds, and a panelled galley, cloakroom and toilet—wa prepared in 3½ days by Lufttransport Union for a single V.I.P. charter flight for a "prominent shipowner." Afterwards the Viking reverted to its workaday guise as a freighter. An account of this operator's Viking work was published in our issue of July 20 last.

HERE AND THERE

Missile Co-operation

PLANS for joint Franco-German research into guided missiles were recently announced after a visit by Defence Ministers of the two countries to the French rocket ranges at Colomb-Béchar in the Sahara. Some of the research is to be shared and Germany will probably provide money and technicians for French tests in the Sahara and elsewhere.

Catapult Designer Honoured

THE inventor of the steam catapult for aircraft carriers, Mr. Colin Mitchell, has been awarded the Newcomen Society's Medal for "oustanding contributions to technical progress in the use of steam."

Instrumental Identification

MEDIUM GREY has been adopted as the standard instrument-panel colour for U.S. Navy aircraft; the dials will remain black. Some new machines already have the new scheme, and older aircraft will have their panels repainted during major overhauls.

Luftwaffe Strength

DURING his tour (as guest of Gen. Nathan Twining, U.S.A.F. chief of staff) of United States aircraft factories and Air Force bases, Lt-Gen. Josef Kammhuber stated that the West German Air Force, which he commands, would have 1,326 fighters and fighter-bombers when it reached full strength in 1961.

Helicopter Old Hand

FROM Piasecki Aircraft Corporation comes news that Mr. Henry Blankenheim has joined the company as production and factory manager of its Philadelphia plant and the premises recently acquired from Bellanca at New Castle, Delaware. Mr. Blankenheim, whose aviation associations go back to shortly after the First World War, was responsible for the Piasecki H-16. He has been with the Brewster, Sikorsky and Kellett aircraft companies and was with the Piasecki Helicopter (now Vertol) Corporation from 1946 until he joined Piasecki.

Breguet Turnover

AN announcement from the Société Anonyme des Ateliers d'Aviation Louis Breguet says that M. Jean Gandilhon has resigned as general manager and been elected a member of the Board. He is succeeded as general manager by M. Henri Ziegler, who is already a director. It is also stated that the company's turnover had increased from Fr. 3.5m in 1955 to Fr. 5m in 1956, and with orders in hand should reach Fr. 6m in 1957 and Fr. 8m in the following years.

Car Bargains

OUR associated journal *The Autocar* publishes today (February 1) an enlarged special-feature issue containing current information on the used-car market, with practical advice as to choosing, and purchasing. In addition all the regular features are included.

Kaman Nuclear Division

THE formation in Albuquerque, New Mexico, of a nuclear division of the Kaman Aircraft Corporation has been announced by the company's president, Mr. Charles H. Kaman. The division will engage in "systems analysis and research in the fields of nuclear / ordnance and propulsion." Kaman Aircraft, the announcement adds, has for the past two years been doing work in the application of certain aeronautical devices to the special weapons field.

Softening the Blow

A PNEUMATIC safety-cushion designed to reduce the risk of injuries in airliner crash landings has been invented in America by Mr. Assen Jordanoff, a pioneer designer. He is demonstrating it—with a French poodle to illustrate the protection afforded to a child on its mother's lap—in a photograph on this page. The cushions, which are rubberized bags stored on the rear of airliner seats, can be inflated in three seconds by a button on the pilot's cushion. The device is shortly to be produced by Micro-Moisture Controls, Inc., of Mineola, Long Island, N.Y.

CRASH BARRIER: Mr. Assen Jordanoff demonstrates his inflatable air cushion, described in the accompanying paragraph.

C-119s Withdrawn

EIGHT of the twelve R.C.A.F. C-119s used to transport United Nations Emergency Force troops from Italy to Egypt are being withdrawn, the other four remaining at Capodichino airfield with some 200 Canadian personnel. R.C.A.F. headquarters, announcing this, have said four Otters and two Dakotas will be operated from Abu Sueir airfield for reconnaissance and communications duties.

IN DISGUISE: This French Spad with Hispano-Suiza engine was apparently thought to be German when the designer of a 1914-18 war memorial window in Swaffham Prior Church, Cambs, depicted it with a black cross on its fuselage. Underneath is the aggressive inscription: "Though they climb to the Heavens thence, I will bring them down."

The author of this article is seen in the centre of the group above with his senior Britannia Fleet executives and officers. From left to right: Mr. D. E. Speigal, base engineer; Mr. D. J. McAllister, senior technical officer; Mr. E. J. Curwood, fleet engineer manager; Capt. W. B. Houston, fleet manager; Capt. A. S. M. Rendall, flight superintendent; Capt. F. W. Walton, officer in charge of training; Capt. F. A. Taylor, flight captain.

BRITANNIA PRELUDE

Background to the Introduction of a New Airliner

By CAPTAIN W. B. HOUSTON, A.F.R.Ae.S., Fleet Manager, Britannias, B.O.A.C.

THE Romans called our country Britannia. Charles II thought there ought to be a symbolic "Britannia" on our coins. He had a particularly attractive girl-friend at the time called Barbara Villiers, Duchess of Cleveland, and she was chosen as the model. No record remains, so far as we know, of Barbara's vital statistics; but, undaunted, Doctor Russell of Bristol Aircraft has managed to produce another good-looking Britannia, even though she has a sharp nose, a twelve-foot waist-line and a prominent rear end. This model is no hot-tempered mistress of men but a gentle giant, submissive, tractable and kindly; or, in the words of one of our B.O.A.C. captains, ". . . a very fast old lady."

The Corporation has put into service many aircraft types already well tried by others, but the Britannia was raw from the makers. Our task was another "Comet exercise." This was not just another piston-engined aeroplane; it was new and revolutionary. B.E.A. had ploughed a parallel furrow before us. We talked to them and flew in their Viscounts. We are indebted to them for their unstinted help.

The Bristol Company produced a flying machine. We had to turn it into an operational airliner fit for passengers to fly in.

The writing of the operations manual was perhaps the major operational task. Every word in the book got there after its justification had been proved. Every procedure, technique, emergency drill, chart and diagram found its place after months and months of hard work and hard thinking by highly experienced flying staff and technicians. A new, highly streamlined navigation procedure based on that evolved for the Comet was worked out, tested on the route to Johannesburg and polished to perfection. Characteristics of performance began to emerge. For instance, it was found that the reduction in T.A.S. to achieve long-range cruise was only 25 knots, whereas in a piston-engined aircraft such as the Douglas DC-7C the loss is 50 to 60 kt. Thus inaccurate wind forecasts are not quite so painful to the Britannia. We found, too, that the descent speed could be stepped up from 190 kt to 225 kt without affecting spar life. This will save about three minutes on each sector without using any more fuel.

Cabin service was worked out in detail by experienced cabin crews who gave the B.O.A.C.-takes-good-care-of-you treatment to cabins full of "guinea-pig" staff. Many a good free meal has been enjoyed in the process.

Much of the Bristols' overseas flying was done by our crews. This was a typical example of the mutually beneficial back-scratching which has pervaded the project during the last three

ILLUSTRATED WITH "FLIGHT" PHOTOGRAPHS TAKEN AT LONDON AIRPORT LAST WEEK

BRITANNIA PRELUDE . . .

years. Concurrently with the Fleet's work the engineers worked out overhaul schedules, spares requirements, technical improvement, maintenance methods. Crews were trained, engineers were trained, equipment was built or bought, stores were stocked. New equipment and spares were positioned at all stations on the route. The Sales Branch arranged demonstration flights, sales clerks and agents were flown in the aeroplane. Advertising schemes were worked out and prepared and publicity was nurtured.

Delay in commissioning the aircraft, caused by technical troubles (referred to later) caused elaborate plans to be rearranged. But now the formative months are over and the work of the past will mingle imperceptibly with the future. If the work of the crews appears to be easy and even leisurely, that is their highest praise: it is praise, too, for the men who evolved the procedures and techniques and then taught them.

The small band of flying staff who formed the Britannia Fleet nucleus in October 1953 quickly formed their views on this new airliner. But what would be the reaction of the crews when they were transferred from other aircraft? True, the Britannia was new and fast, but they had all been flying American aeroplanes. During the war and since, B.O.A.C.'s fleet had been predominantly American. Of the 755 pilots in B.O.A.C. only 48 flew with Imperial Airways. All the British Airways pilots and most of the ex-R.A.F. pilots have spent their civil careers on American aircraft—which they like, because they are good aeroplanes. The "only-America-can-build-airliners" outlook of some was shattered by the Viscount. Perhaps Bristols could also compete with the traditional American excellence: perhaps, like Vickers, they could also move ahead. But when the new members of the fleet flew in the Britannia there was no need for salesmanship: they liked it from the start. Britain might not swamp the world with airliners but what they did produce was good. The now-forgotten wishy-washy praise for the Viscount must not be repeated. Men who knew aeroplanes knew the Viscount was the best thing of its kind in the world; but they got little attention from the world until Viscounts were bought by the Americans. Men who know aeroplanes know the Britannia to be the greatest aeroplane in its class in the world today.

Picture, if you can, a crocodile—a crocodile of one hundred soldiers filing aboard an aeroplane, each with a rifle, pack, tin helmet and inch-thick boot-soles, while lorries feed kitbags for the lot into the holds. Then, with a crew of ten, the aircraft leaves on a 7½-hour flight and cruises at 320 kt. That is not the limit of the Britannia's capabilities—it is an account of what it has already done many times. And this is the "small" Britannia, not the bigger long-range version.

Pilots and crews have loved and hated aeroplanes or been apathetic about them. Maybe the highly skilled, technically trained men who handle modern airliners are unromantic—about their work, at any rate—but they can become very attached to some aeroplanes and not to others. The Britannia may be "any pilot's aeroplane" or "a big Anson" (the accolade); but whatever they say about it, it is always kindly. They like it.

How can seventy tons of complicated metal evoke respect and affection? A pilot's hands and brain act in co-ordination to create

The Britannia flight simulator at London Airport, made by Redifon. "More complicated than the Britannia," to quote the author, "it is regarded by harassed instructors as a heaven-sent gift and by the unfortunate trainee victims as a device of the devil." The "victims" in this picture are E/O. Buckley (in the jump-seat), F/O. Gaynor (left-hand seat) and Capt. Gosling.

The Bristol Proteus overhaul bay at B.O.A.C.'s London maintenance base. When this picture was taken the de-icing modifications were being incorporated (see page 136).

a personal impression of the aircraft he is handling. He feels the tremendous power of the Britannia, but he knows it to be power so well controlled that as he takes off at full weight he can cut the 4,000 thrust-horsepower of an outboard engine and, without effort, take the air in a fast climb. He could do that even with the stick held hard back from the start of his run. Precision handling is what the Britannia normally gets; but it is comforting to know that ham-fisted manœuvres don't bring disaster. If a pilot deliberately mishandles it, it gently forgives the abuse. If he stops two engines on one side it maintains height as he weaves a crazy pattern. If he comes in to land with two dead on one side and without flaps, he finds it as easy as a normal landing. There are no tricks to learn. The Britannia forgives blunders graciously and slowly. The Britannia is a safe aeroplane.

But let's go back to October 1953, when the fleet was formed and consisted of the flight superintendent, Captain A. S. M. Rendall; Captain F. W. Walton, the officer i/c training; Captain T. H. Farnsworth, development captain; and myself as fleet manager (non-operational). The task—to prepare the training plans and operational procedures and organize a structure to operate a fleet of the largest airliners in the world. Among many other things, we had courses at Bristols' engine school, and aircraft service department, and at component manufacturers. We flew many hours in the Britannia. In due course the Master of Test Flight, one Bill Pegg, put pen to paper to the effect that the three captains could venture forth in the old workhorse G-ALBO—on their own. By this time the solid shape of the job to be done faced us and we threw away our crystal ball. Eventually, on December 30, 1955, uniforms (grown tight and smelling of moth balls) were donned and G-ANBC and G-ANBD were delivered to B.O.A.C. at London Airport. At 0800 hours next morning we began our intensive training programme, which was to continue at Hurn seven days a week, starting at 0730 each day and frequently finishing at midnight.

One of the peculiarities of airline flying is that in a large fleet it is possible to operate for two years or more and fly with a completely different crew on each flight. This means that every operating procedure and drill must be so precisely taught that each man knows exactly what he is expected to do at every stage of the operation, and—more important still—he knows what every other member of the crew will do in any given set of circumstances, even though he may never have flown with them before.

From the time a pilot is posted to the Britannia Fleet until he first commands a Britannia on a passenger-carrying service, this is what happens to him. First of all he goes to the training school

for an intensive technical course on the airframe, systems, electrics and engines, during which time particular emphasis is laid on the electrical system, which is the very heart of the Britannia. Extensive use is made of working rigs that enable all the more important systems and procedures to be operated and the correct indications given (e.g., the electrical panels can be operated as they would be in the aircraft, an engine can be started, the ice-protection systems used, the fuel system operated, and so on). Use is also made of sectioned components, an "exploded" power unit, films and a model pressurization system. Hundreds of colour transparencies are projected to show in detail every part of the aircraft and engines.

On completion of this course there is a Corporation technical examination to pass. At this stage the unenlightened sometimes think that their troubles are over. This blissful phase lasts no longer than a week-end, by which time an intensive instrument flying course of one week's duration will have started on the flight trainer. This is an electronically operated training machine in which the first pilot's side of the Britannia cockpit is faithfully reproduced and which is used primarily to carry out training on instrument flying procedures such as airways, radio range, radio beacons and instrument approaches. Circuit and overshoot flying procedures can also be practised.

The next phase, which lasts for two or three weeks, is a course on the Britannia simulator. It is an exact replica of the flight deck and can be flown and operated in exactly the same way as a Britannia, the only difference being that it never leaves the ground—a characteristic which has some merit in view of the horrifying combinations of failures and disasters which can be simulated. More complicated than the Britannia in many ways, it is regarded by harassed instructors as a heaven-sent gift and by the unfortunate trainee victims as a device of the devil. Thorough and detailed systems handling, including every possible fault and rectifying action, can be carried out, followed by flight training of a complete crew. Complete route flights from (say) London to Cairo can be realistically simulated in detail.

First there is a study of the weather situation along the route and at the terminal airfields. There is the usual briefing on radio aids, airfield serviceability and navigational warnings. The flight plan is then worked out, the fuel requirements determined, the load-sheet prepared and the pre-flight check made on the aircraft. During this check several faults will be found which must be rectified by the crew. Complete facilities are provided; the ground engineers are on intercom for starting engines, ground power is available, full air traffic control is provided, radio aids along the route all work or become unserviceable as is their wont. The effects of weather conditions, such as winds, icing and turbulence, are all simulated.

Having got permission to start up, taxi out, take off and set course for Cairo, the crew soon find that the faults console, operated by the instructors, is being used to reproduce every conceivable failure. The hydraulic system won't off-load, due to a blown fuse; the normal throttle system fails on one engine; the gyro compass fails; an alternator trips out; an inverter fails; an artificial horizon topples; the fire bell rings, red lights flash as a fire warning, and failure of No. 1 engine takes place. Then the ice detectors indicate that icing is being experienced, so all the ice protection systems are then switched on—and another red light flashes as a wing overheats; and the tail de-icing timer fails and has to be changed. The compressor r.p.m. and torque on No. 2 engine suddenly fall off, the jet-pipe temperature rises rapidly and the engine is shut down by the overspeed limiter.

Ah well, Rome is just to port, so clearance is obtained to land there—landing conditions are marginal, but just within limits on I.L.S. What's that? The I.L.S. equipment is unserviceable? All right, we'll use the radio range. On final approach on instruments Rome reports a sudden deterioration in landing conditions and the airport is closed. Now what? Malta is the only airfield open. Some fifty miles from Malta, No. 3 propeller overspeeds and the engine is shut down. Distress signals are sent out and the air/sea rescue organization alerted. Can the aircraft reach Malta descending on one engine? Rapid calculations are made and the answer is no, so preparations are made to ditch. At the moment of contact with the presumably cerulean water the cockpit is plunged into darkness. The flight-deck door slowly opens and a haggard sweat-sodden crew totters forth into the light of day. This is no time for ladies who flinch at man's more robust language to be present. Fortunately, of course, such nightmarish combinations of failures do not take place in real life, even on Friday the 13th; but individually any one or two of them may occur, and all must, therefore, be practised until the rectifying action becomes routine.

After two weeks or so of simulator training the A.R.B.-type technical examination is taken and a flight performance course is then begun, covering such things as calculation of take-off weights, landing weights, net flight paths with one engine out, V_1 speeds, and other performance problems. Another A.R.B. examination follows.

The next stage is a two-week course covering flight planning, cruise control, navigation procedures, search radar, distance-measuring equipment and other radio equipment peculiar to the Britannia.

The flying-conversion course then takes place at Hurn, involving such exercises as accelerate/stops, single and double engine failures during take-off, three- and two-engined overshoots and landings; flapless landings; and instrument flying and other procedures suitably enlivened at the right time by the simulation of such faults as engine failures, throttle failures, flame-outs and bus-bar earth faults.

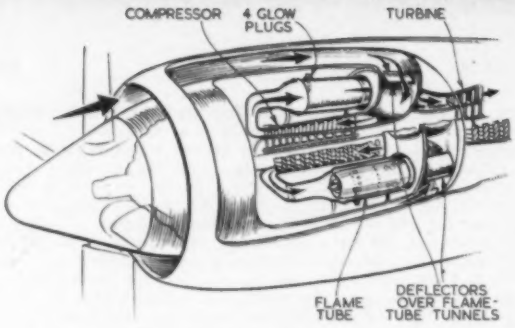
The last stage of training then follows as each crew operates the aircraft along the route under supervision, after which they are finally checked out and cleared for passenger-carrying services.

* * *

Visitors descended on Hurn like confetti. They flew the Britannia, examined it, photographed it, talked about it, sat in in, argued about it; one was even sick in it. But they were welcome; we liked them, and we hoped their visits were valuable—we think they were. We certainly gained—we got publicity from their cameras and writings, they spread (we believe), goodwill for us. Their intelligent comments and criticisms warded off complacency and cockiness. It may be odd to thank them for coming, but we do.

The first phase of training began on December 21, 1955, and ended on June 29, 1956. During that period 2,122 landings were

G-ANBF undergoes a check at B.O.A.C.'s Britannia maintenance hangar at London Airport.



***Baffling problem:** This simplified sketch shows the positions of the two deflector plates fitted as the final cure—after months of exhaustive research—of the de-icing problem. Note also the glow-plug—one in every other flame-tube. The photograph shows the deflector plates fitted over Nos. 1 and 8 (adjacent) flame tunnels only.*

BRITANNIA PRELUDE . . .

made in 1,547 flying hours. Except for freezing of the flying-control gearboxes, referred to below, there were no significant troubles. With only minor adjustments the Proteus engines ran trouble-free; there was not a single unscheduled engine change. To pilots reared on a diet of ignition troubles, piston seizures and vibro-massage from piston engines this was really something—this, and the fact that the Britannia can fly without effort with two dead engines, engendered a happy content they had never before had in the air.

In spite of our original misgivings, it must be freely admitted that the electrical system works with the regularity of a household lighting system. The undercarriage has given no significant trouble whatsoever and G-ANBD, for example, has already completed more landings during training than a Britannia will normally do during the course of two years of route flying. This is pretty high praise for the brakes, the tyres and the hydraulic system.

There were two major setbacks. One filthy night in January 1956, when a Britannia was parked in the open at Hurn, the flying-control gearboxes froze up. An east wind, driving sleet and sub-zero temperatures, had revealed a serious defect. This happened when arrangements for introduction of the aircraft into service were fairly well advanced.

What is sometimes described as "fire-brigade action" set in. Modifications were started the same day, and for some time the aircraft, which were being used for training, were flown in "zero-plus" temperatures. The action was prompt and efficient and the problem faded out.

But on April 3, 1956, a bigger and tougher snag hit the Britannia. G-ANBE was flying from Livingstone to Nairobi when one engine after another started to "bump"; then worse happened—one after another they "flamed-out."

Briefly, an engine "bump" occurs when the flame in one or more of the flame-tubes is extinguished and then relit. It is, of course, relit from the other flame-tubes through the connector tube. As the relight occurs a "bump" is heard and felt. It would probably pass unnoticed by anyone who was not concentrating, and in some cases is so slight that a momentary fluctuation of the torque-meter is the only evidence of its occurrence.

A "flame-out" means that the eight flame-tubes are extinguished simultaneously. The engine then loses all power. Fortunately, the Proteus 705 can be relit immediately without trouble, so this most disconcerting phenomenon has never placed the aircraft in a hazardous position. In addition, the Britannia will hold the same height for some five minutes on two engines, and will take about 1½ hours to drift down to 8,000-10,000ft, where it can hold height indefinitely on two engines.

The Proteus had been given the full treatment at Ottawa, when it went through winterization tests without fault. It had, in fact, proved to be the most successful engine ever tested there. Two had then been installed in an Ambassador and flown with a spray-rig in front of each engine. Here again the tests had been a success. The engines had consumed colossal quantities of ice in cakes and sticks without trouble.

It didn't seem to make sense that at sub-zero temperatures at about 20,000ft over Africa ice could cause bumps and flame-outs. The exact mechanics of flame-out are still being investigated, but this much is known. When dry-ice crystals enter the air intake and accumulate on corners and "pockets" in the intake cowling, the build-up of ice will eventually break away and cover or partly cover the entry guide-vanes. Then the engine bumps or flames out, according to the magnitude of the ice fall.

It seems that the explanation may be something like this. At altitude the compressor is operating close to the "surge line," the ice fall is sufficient to create instability (rather analogous to "back pressure") and the combustion chamber is thus starved of air. At low altitudes the compressor is operating further away from the surge line and therefore no trouble is experienced.

Clean up the air intakes and add heat at the trouble spots—that was the line of attack; and it was wrong. Heat was the main cause of the trouble—heat in the wrong place. It took a long time and an immense amount of work to find the cure. Seven missions were flown from Filton to Entebbe in Uganda by Bristols. Complicated instrumentation was fitted, TV cameras were installed in the cowling. Modifications were made and thrown away as useless. Mods were re-modded. Many of them made the engines behave worse than ever. Then the right answer was found.

Now the engines are ready for passenger service. The final solution sounds so simple. Glow-plugs have been fitted in four of the eight flame-tubes and metal deflectors have been fitted over two flame-tube tunnels. A number of angles have been faired and holes sealed, but these are minor modifications. The glow-plugs and the deflectors produced the "fix."

First the glow-plugs. These are 1½in-long, 1⅛in-diameter hollow platinum-alloy rods which are screwed into the body of the flame-tube like a sparking plug, so that they project into the heart of the flame. It is a characteristic of flame-outs that the airflow is chopped for only a fraction of a second. It returns while the hot rod is still incandescent, and the mixture is immediately relit.

The fitting of glow-plugs is a sensible insurance against flame-outs. They have no moving parts, no electrical connections and require no maintenance. They have a "life" greatly in excess of the flame-tube. A glow-plug fulfils all the requirements of a perfect piece of equipment.

Now, the metal deflectors. The hot gas from each flame-tube is ejected rearwards through tunnels which pass through the air intake annulus (see sketch). The cold, dry, feathery ice crystals which pour into the intake strike the warm tunnels.

This is where a snowball effect sets in. Squeeze a handful of cold, dry snow and it solidifies into a snowball: the compression melts the crystals, which then fuse. The heat of the tunnels had been having exactly the same effect. A cake of hard ice about 2½in x 5in was built up. Eventually this ice pancake broke away and smacked on to the entry guide-vanes like a blanking plate. The flame-out followed. It was now clear why the Ottawa tests were so successful. Large lumps of ice don't stick—they clank harmlessly through the engines like a pin-table ball. But the TV cameras showed the dry ice forming on two of the tunnels.

The next move was to fit deflectors over the hot tunnels to direct the crystals past them. These deflectors are alloy sheeting with a 15-thous. clearance from the tunnels. The deflectors have the same temperature as ambient air and the ice crystals stream past and bounce off them like dust particles.

But at no time did the Britannia stop flying. Training and testing went on; then Nasser grabbed the Suez Canal. Troops were flown out to the Mediterranean in 34 Britannia flights. This helped a lot. These flights brought further technical and operation refinements apart from the considerable help they were to crew training. After a lull the trooping charters came in thick and fast when the shooting started in Egypt. A further thirty-four were operated.

When we began flying the refugees out of Budapest we were pleased that we had an aircraft to do the job. We fitted 115 seats in each Britannia and pushed them day and night until we had completed 29 flights, carrying 3,300 refugees to the freedom of the Western world—until there was no room in Britain to house them. This was not a Britannia party—every available aeroplane was commissioned—but we think there will be many Hungarians who will always remember the Britannias and their crews, for in their misery they were given help; their fear was banished by kindness. By mid-January 1957 our Britannias had carried 10,511 fare-paying passengers.

Now and then, aeroplanes get tossed about pretty violently when on their lawful occasions. Once in a while an airliner disintegrates; but once in a while is too often. If you read about

"If you read about the benefits of search radar they sound almost too good to be true . . . that's what they tell you, and they're right." *A close up of the Britannia's nose, housing Ekco search radar.*

BRITANNIA PRELUDE . . .

the benefits of search radar they sound almost too good to be true. Never again need your aeroplane plough through the core of a cu-nim; smaller cloud-circumnavigations will save money; schedules can be held at night through the Intertropical Convergence Zone and the monsoon; seeing the ground below makes navigation easier; the nervous apprehension of the crew is transformed to an "It's-a-shame-to-take-the-money" outlook. That's what they tell you—and they're right.

Even today there are folks with an understanding simple and unschooled who believe the autopilot to be a luxury, the sole purpose of which is to save the pilot the trouble of hand-flying. Ten years from now the same simple souls, or their successors, will think search radar a similar luxury. The fact is that no airline can afford not to fit search radar. Its contribution to efficiency and economy is too great to be ignored.

On development flights the Britannia has used search radar in reverse. It has used it over Uganda and the Congo to find the cores of some of the toughest cu-nims in the world. It would be false heroics to say that anyone on board enjoyed the experience. It seemed as if Nature flew into a towering rage at the effrontery of these men who defied her strength; and in her uncontrollable rage she tried to tear their aeroplane apart. It was thrown up, down and sideways; its whole structure flexed and strained; the nose was bashed in by hail; violent explosions and incandescent flashes filled the cabin as clouds discharged their millions of volts through the airframe. Where the Farnborough tank tests left off, Nature took over—and both of them lost. The Britannia is as tough an aeroplane as has ever been built. (The stressmen, it may be added, were quite happy from the start. They had books full of calculations to *prove* the aeroplane wouldn't come apart. And they had another reason for being happy: they were 4,000 miles away in an office.)

Restfulness of mind and body is not a statistic. For that reason we see no convincing charts with parameters of fatigue *versus* hours flown. You just get to know about these things when you fly in aeroplanes. It soon dawned on all those who flew in the Britannia that they were stepping ashore feeling fresh. A 24-hour flight produced no ear-singing, body-twitch, eye-tingle or dead-beat exhaustion.

Naturally, the Britannia is pressurized, and that gives a decent supply of oxygen to breathe. Yet so are all modern aircraft. But the Britannia is humidified, and many modern aircraft are not. Noses do not dry up and bleed when blown, eyes do not smart and the skin remains moist. The Britannia's noise-level is low. No aeroplane is *quiet*. In the confined space of a fuselage it would be dreadful if it were. Noise gives privacy. Silence would transmit snores, children crying, lavatory-flushing and what-have-you to all ears. In the Britannia the noise is right. There are no high-pitched whines or whistles, no rumbling, no roars or thumps. The sound is low, smooth, unobtrusive.

No aircraft is completely free of vibration; there is always some, but in the Britannia it is truly slight—the surface of your coffee or Scotch remains motionless. Pencils can be stood up-ended on tables. Vibration is insidious. The body becomes fatigued if it is subjected to hour after hour of high-frequency judder. If there is little vibration one of the major factors in aeroplane-travel weariness is eliminated.

Humidification, unobjectionable noise and a freedom from vibration—these, then, are the three main reasons why crews and passengers can fly all day in a Britannia without that common desire to fall into bed and be left alone in quiet and darkness for the next twelve hours.

If one writes in praise there will inevitably be a charge of bias; however, convincing as self-assurance may be, there is the sneaking belief that the charge is valid. And yet it is not easy to find non-existent virtues in an aeroplane which for three years you have seen in all its moods, whose systems and structure have lain naked before you. In the hands of crews and technicians an aircraft has no self-defence; neither paint nor fine trimmings will hide its flaws and birth-marks.

But worth can be assessed only if that which stands on trial is ranged with the greatest of its kind. There were more than thirteen good men and true who knew the world of aeroplanes and who were merciless and inflexible. There was much they didn't like. Often Bristols agreed, sometimes they didn't; but always they listened, and always they acted. The objective was the same—to create an airliner which would be the best in its class in the world. An airliner which would not accept existing standards but would set new ones. And it does.

The unique maintenance docking employed by B.O.A.C. for major Britannia overhauls. It incorporates power-operated lifts on both sides of each engine, telephones, power and compressed-air points, and a fuel-tank-ventilating system. It permits quick positioning of the aircraft by means of hinges and rollers and was designed by B.O.A.C. and Roger Fretterington, Ltd., of London.

"Flight" photograph

BRITANNIA: the Pilot's Airliner

By CAPTAIN LINCOLN LEE, B.O.A.C. Britannia Fleet

A GREAT many people, not the least amongst them being the prospective passengers, are delighted that the Britannia is about to go into service. But I can think of none who are more pleased than the pilots of B.O.A.C.'s Britannia Fleet. After only a comparatively few hours of route-flying it endeared itself to me as a trunk-route aircraft, and I am sure that that applies to all the other pilots of the fleet. As a route aircraft the Britannia has advantages which make it a really tremendous improvement over the types which it is replacing, and it is those advantages which I want to outline in this article, as distinct from the economic and more general advantages which this journal has already well described.

Search Radar. The first really outstanding advantage of the aircraft is its search radar. I have never been able to comprehend how any passenger, let alone somebody on his first flight, endures the turbulence inflicted by a cumulo-nimbus. Thunder-clouds have always provided the most unpleasant feature of flying, and my modest fifteen years of experience with them has made me dislike them more and more. Search radar eliminates this most frequent and serious of worries. Just like that; it is almost too good to be true. No pilot who has once weaved effortlessly through the activity of the Intertropical Convergence Zone by casual reference to the radar screen will want to fly without it.

The advantage of the search radar does not end there. As a navigational aid alone it may be well worth while. Any prominent landmark within 120 miles of the nose, be it lake or island, mountain or coastline, will show on the screen, giving an instantaneous relative fix on the dirtiest, cloudiest night. On the routes which the Britannia 102 will operate the terrain is such that once crews gain experience they may be able to get their position by reference to the screen during a considerable percentage of the time. Another advantage, though of course with limitations, is that it can be used for ground-speed checks, and in this connection it is interesting to know that even small ships give a return on the screen.

The Aircraft Itself. To my mind it stands to the credit of the designers that, despite its size and speed, there is little unorthodox in the handling of the Britannia. There is no disputing that it is a lovely aircraft to fly, and is not in any way hot to handle. Above circuit height one's feet are not put on the rudder; otherwise there is little one can say about the controls. Some of the panel layouts are a vast improvement over those of older aircraft. The fuel panel is exceptionally good, telling you everything you could want to know about the fuel system at a glance. The electrical and fire panels are also excellently designed. Even the roof radio panel, which at first glance seems confusing, is an attraction. In particular, this is so because everything you need is at your finger-tips—a lavish array of equipment. D.M.E. and I.L.S., besides two A.D.F., two U.H.F., and two H.F. sets, are all within easy reach of the two or three pilots who may be operating the aircraft. To utilize this equipment we now have the new light headsets, which are a great improvement when one has to be on duty for umpteen hours. Independent of the general interphone system (and just as well) we have a first-rate public address system.

Horses to Spare. There is little point in enlarging on some of the minor features of the flight deck. I myself find the sun visor surprisingly useful, while the pilots' seats are far better than the ones I have experienced in the past. It is the bigger things which count, and the one which appeals to me most is the feeling of power which the Britannia gives. I am not a megalomaniac, but tremendous power is highly desirable at take-off, and that the Britannia really has. I haven't experienced a genuine engine failure on the aircraft, and it is probable that the Proteus will fail very rarely. But I think one can say that the effect on performance is so slight that one of the pilot's worries may be that he will not notice the failure at once.

One of the smaller items which does call for comment is the height lock incorporated in the excellent S.E.P.2 autopilot. With potential destruction hurtling above and below one on the airways and advisory routes, and often within 300 yards vertically, a height lock is really essential. I must admit I felt uneasy about the stalling-potentialities until I tried this one. Not to worry: almost as soon as power falls off the autopilot disengages.

Delays and Decisions. For the line pilot it is always fascinating to watch the diagnosis and investigation of a difficulty such as the dry-ice flame-out. During the delay we had to endure the chaffing of friends, including frivolous references to the name of the engine,* but there was great admiration for the firmness of the decision taken by the management of B.O.A.C. and Bristol Aircraft. A popular story went the rounds two or three months ago about the trials then being carried out at Entebbe. According to this, the technicians had a television camera installed in the intake of a Proteus, so they could watch on the screen in the cabin a clear picture of a section of the entry guide-vanes. On each occasion the vanes showed clearly until some minutes after the aircraft entered dry-ice conditions; then pieces of ice were seen to shoot back and lie momentarily on the vanes. And each time, as the ice disintegrated and went into the compressor, familiar words would appear on the TV screen: "Normal service will be resumed as soon as possible."

Joking apart, this was an occasion worthy of note, when manufacturers, operators and outside advisers all worked together with firmness, ingenuity and great success; and, because of that, "normal service" is in fact being resumed without an excessive delay.

* *Chambers' Dictionary: "Proteus, the sea-god, fabled to have power of changing himself into an endless variety of forms: variable: inconstant."*

Eastleigh Airport, Nairobi.

Impressions of a B.O.A.C. Proving Flight to Africa

By J. M. RAMSDEN

ILLUSTRATED WITH "FLIGHT" PHOTOGRAPHS BY THE AUTHOR

BRITANNIA DRESS REHEARSAL

WITHIN one brief, happy-go-lucky week of its maiden flight on March 26, 1922, the new D.H.34 limousine-of-the-air was carrying fare-paying passengers between London and Paris. The philosophy in those days was "It'll be all right on the night," and usually it was.

Today the Bristol Britannia 102, four-and-a-half years after its maiden flight, is entering B.O.A.C. service. Happy-go-luckiness has had no part in the evolution of this airliner: the Britannia has received the roughest pre-service shaking down of any aeroplane to date, bar none. As everybody knows, pre-tested exhaustively though it was, the Britannia hit unpredictable engine-icing troubles when it went on its route trials, and the inauguration of services had twice to be postponed (in April and September, 1956).

It is not the intent of the present story to weigh the heaviness of these blows to B.O.A.C.—the revenue lost, the costly stop-start-stop-start of the elaborate training machine. All this, now that it can be regarded in perspective, was the price paid for tuning the Britannia to the highest possible pitch of faultlessness before it carried passengers.

Elsewhere in this issue Capt. W. B. Houston, Britannia Fleet manager, tells how the organization for administering, flying and maintaining the new fleet was built up. The proof of his organization was to be found in the route trials, and it is with one of these, which I accompanied, that this story is concerned.

Like the six proving flights which preceded it, this one was to conform in every detail to an actual service—from the fuel management procedure to the dinner menu. Hence the title of the crew's memorandum from Fleet Manager, Britannias: "Britannia Token Service BPF 011." The only difference between our flight and the real thing was that the passengers making the most of the hedonistic pleasures of Britannia travel were trainee and supervisory crews—25 in all under the command of Capt. W. R. Hutcheson—comprising four captains, six first officers, three navigators, three engineers, five stewards, and four stewardesses. The rest of the total of 65 on board included B.O.A.C. technical staff, observers from Bristol (including test pilot Ken Ashley), and representatives of de Havilland Propellers, Ekco, Normalair, Teddington Aircraft Controls, and the M.T.C.A.

The flying crews had been thoroughly checked out on the Britannia at home, first on the flight simulator and finally on the aeroplane itself. There were few days during last summer on which people in the Bournemouth area did not see or hear the endless comings and goings of Britannias at Hurn airport. And practically all of the crews—being ex-Argonaut Fleet—were familiar with the airports down the route to South Africa.

For the flying crews, our journey, if not exactly an end-of-term outing—though in its lighter moments it may have seemed like it—was the culmination of a lengthy term of classroom work and flying training. Culmination is perhaps too final a word: continuation would be more appropriate. There is enough to be learnt on proving flights for each man to be required to experience at least two. For example, the intricate flight-planning procedure (described later) requires regular practice before full confidence can be gained.

From the moment our Britannia, G-ANBC, was a receding blip on London Radar, training had begun. Europe means airways, and airways-flying provides plenty for the crew to do and

"In the B.O.A.C. Khartoum station manager's office, shuttered and fanned against the heat, the icing level is found to be 16,000ft and the flight is planned accordingly . . ." From left to right, F/O. John Goulden (holding cap); Nav/Off. Geoffrey Morell; Capt. Howard Fry; B.O.A.C. Khartoum manager (smoking); Capt. W. R. Hutcheson.

Turboprop neighbours on the Frankfurt Rhein Mein apron: an Air France Viscount as seen from the door of the Britannia.

"The intertropical front . . . its mighty forces locked up in cloud of mesmeric loveliness . . ." The tailplane, as seen from the rearmost window, appears through the Perspex slightly distorted.

BRITANNIA DRESS REHEARSAL . . .

to learn—although the Britannia poses no special problems, as Captain Lee testifies in his article on page 138. In some ways airways flying is easier: there is, for example, the S.E.P.2 auto-pilot height-lock, with which the flight-plan altitude is pre-selected and thenceforth automatically maintained. There is no need for constant observation of the altimeter—a great boon when on airways.

* * *

We arrive over Frankfurt Rhein-Main 2 hr 19 min after leaving London, fly in over the *autobahn* (a very fast 12 km to the city), let down over a mighty phalanx of parked Globemasters with arctic-scarlet tails, and touch down as a PanAm DC-6B takes off reciprocally from the parallel runway. We are whisked importantly off in a yellow-striped multi-trailer bus to the terminal building, whence we view the apron stand—jam-packed with K.L.M. Super Connies, B.E.A. Viscounts, Swissair DC-3s, Flugdienst Vikings, PanAm Stratocruisers. It will not, I muse, be very long before Frankfurt's terminal area will need very considerable enlargement.

From Frankfurt it is but a two-and-a-half-hour Britannia-time to Rome—our first night stop. It is dark when we join the Ciampino circuit. Glowing comfortably after a five-course dinner, I look down through the fuzz of the Proteus effluxes at the fabulous lights of the world's most beautiful city.

This, for passengers, is the moment of transition from the relaxed semi-torpor of the cruise to the bustle of collecting together thoughts and belongings for the landing. The note of the engines has changed, the aircraft is bucking about more, the pressure discharge valves are hissing, the stewardess has her hat on. One senses the taut moments of the approach; almost unexpectedly the runway threshold lights appear outside the window, the engines are cut, and there is the familiar gentle shudder of the touchdown. Immediately the engines roar into life again with the D.H. propellers in reverse pitch; there is a momentary lick of pale yellow flame from the Proteus exhausts, and I get a faint momentary whiff of paraffin.

One of our propellers, incidentally, had blades of the new solid light-alloy pattern with rounded tips. They are being experimentally fitted to Britannias as an alternative to the square-tipped hollow-steel-blade units.

We turn off at the intersection, and the stewardess is cooing her set piece over the public-address system: "This is Ciampino Airport, Rome. Local time is half-past eight. The temperature outside is 79 degrees, and I do not think you will need to wear your overcoats . . ." We disembark from the conditioned coolness of the Britannia's cabin into the heat of an Italian autumn night—a heat momentarily intensified as we descend the steps past the jet-pipes.

In Rome I have my first experience of the rapidity with which B.O.A.C. crews change out of their uniforms into mufti.

There is moonlight on the Mediterranean as, next evening, we climb on course for Khartoum, 2,170 miles away. It was a longish take-off with full fuel on board for seven hours plus reserves. Because kerosine is cheaper in Rome, the tanks can be filled right up when there is no payload limitation: this permits a faster cruise without the extra fuel cost. On such a long haul as Rome-Khartoum, the "high-stepped" cruise technique gives the best economy, but the "low-fast" technique is obviously preferable if it can be had for the same price (a point that will be enlarged upon later in this article).

Dinner is served over the Mediterranean, and I marvel at the slickness with which sixty passengers, between cocktails and liqueurs, are given soup, salmon salad, grilled lamb cutlets, fruit jelly, cheese and coffee. The B.O.A.C. reputation for superlative service is zealously upheld: it is of that rare kind which, though attentive of every detail, is yet unobtrusive.

Four of our more hefty captains and first officers return from up front to their seats at the aft end of the cabin for dinner, and the captain in command reports a consequent drop in airspeed of four knots.

Later the main cabin lights are switched out, leaving only the occasional narrow cone of light from an individual reading lamp. In the black abyss outside the windows all I can see is the winking reflection, on the wing, of the mid-fuselage navigation light. I manœuvre my seat into the fully reclined position, draw up my woollen rug, and very soon succumb to the drowsy hum of the

The navigation station of the Britannia. Note the Ekco search-radar presentation, seen here "painting" Lake Nyasa 100 miles ahead.

Crossing the confluence of the Blue and White Niles on the approach to Khartoum, with Capt. Gosling in command.

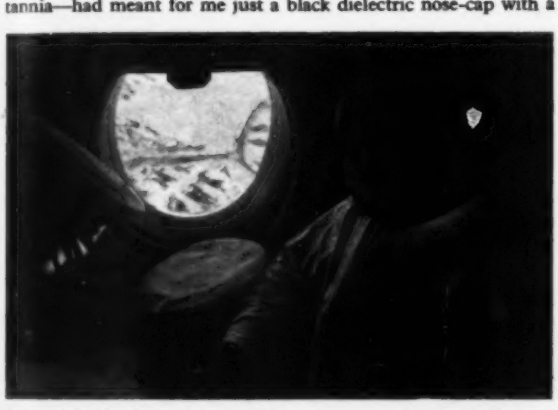
turbines. The Britannia's passengers are asleep 20,000ft over the Sahara.

It is still dark when, seven hours after take-off, I wake to find we are circuiting Khartoum. So fast does the African dawn break that it is light by the time we touch down and step out into the sticky heat (90 F) of an early morning in the Sudan.

Captain Hutcheson decides that on the next sector (Khartoum-Nairobi) we shall do some deliberate rough-weather-hunting, to give crews experience of flying the Britannia in African storms and to demonstrate the Proteus de-icing system. Reports in the B.O.A.C. Khartoum station manager's office, shuttered and fanned against the heat, say that the icing level is 16,000ft. The flight is planned accordingly. Four times more than the standard 250 kg fuel allowance for de-icing is taken aboard, and the rest of the fuel calculated in the routine way described later.

Take-off run of the Britannia is rarely a payload-limiting factor, and our three departures prior to Khartoum had been relaxed affairs—none of those sudden leaps forward at full power as the brakes are suddenly released. But one of the points to be watched in the tropics is jet-pipe temperature. Each engine has a slightly different j.p.t., and therefore a different ambient reference temperature, which may vary from 24 deg C to 30 deg C. If ambient exceeds this, the engine or engines concerned are part-throttled by 10 compressor r.p.m. per deg C. As this adjustment is difficult to achieve accurately while pounding down the runway, it is done while on the brakes, as it was on our take-off from Khartoum.

The ensuing flight made me a lifelong devotee of storm-warning radar. Until then this equipment—Ekco on the Britannia—had meant for me just a black dielectric nose-cap with a



Capt. W. R. Hutcheson, training skipper in command, surveys Khartoum from the Britannia's flight deck.

dish inside, some little back boxes, and a pair of radar scopes on the flight deck. Henceforth it will be a prerequisite of my travels by air.

Three-quarters of an hour after take-off the *Fasten Seat Belts* notice lights up, and the captain announces over the public address system that the next few minutes "may be rather bumpy." On the radar the grey core of a thunderhead is coming up, and instead of respectfully avoiding it, as we would on a normal service, we are aiming straight at it.

The outers are throttled back to 9,000 compressor r.p.m. (normal cruise: 11,350 c.r.p.m.) to reduce speed for penetration. We are now wrapped in cloud—the brownish-grey claustrophobic stuff of the intertropics which at Britannia height abounds in dry-ice crystals. The engine auto-relighting switches above each pilot's head are already on.

The bumps are slight at first, rather like Comet "cobble-stones" . . . suddenly they increase in amplitude, becoming full-blooded multi-g pitchings (someone later said we recorded a reversal of 4g). The noise is considerable, with the battering of hailstones—at times hitting us from beneath as well as from above—and cracks of thunder as we spark off blue-green sheets of lightning. But the captain, an old hand at flying through African storms in Argonauts, has no trouble in keeping a tight rein on the Britannia (this I am told afterwards).

The experience lasts for but a minute—long enough to enable me to discover that the best way to ride a storm is fully reclined (horizontal if in a Slumberette), and as near to the c.g. as possible. But this is advice that need never be acted upon when the Britannia is in service, thanks to the alert little Ekco radar dish up front. (Later, on the homeward flight, crossing the African coast *en route* for Rome, I was to see our radar in its incidental H$_2$S-type rôle of map-painter. The whole of Sicily and the toe of Italy were clearly portrayed, proving that the cartographers—and our navigator—were right.)

"The only difference between our flight and the real thing was that the passengers enjoying the hedonistic pleasures of Britannia travel were trainee and supervisory crews . . ."

Soon all is sunlight, blue skies, and calmness again. Captain Hutcheson, the training captain, is back in the cabin, giving one of the trainee first officers an extempore oral on the Brittania's air-conditioning system. A B.O.A.C. technician, whirling a wet-and-dry-bulb like a football supporter's rattle, is taking his routine measurement of cabin humidity..

In four hours we are over Nairobi, commercial capital of British East Africa, 5,371ft above sea level, and approaching the red compacted murram runway of Eastleigh Airport. The surface is dry and soft, and selection of reverse pitch blows up a pall of red dust which is still suspended over the airfield as we disembark.

Two days in Nairobi, our considerable enjoyment of which is owed to the efficiency and charm of East African Airways' Mrs. Diana Howard-Williams. And now from Nairobi to Salisbury, capital of British Central Africa—a fast four-hour cruise through clear African skies.

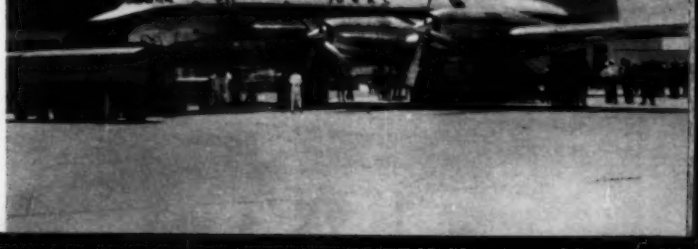
We have left behind us the intertropical front, on its ceaseless pursuit of the sun back and forth across the equator, its mighty forces locked up in clouds of mesmeric loveliness. The difference between the scene outside the cabin windows then and now is profound. On the previous sector—our cabin a kaleidoscope of sunlight and shadow—I gazed upon towering, flat-bottomed thunderheads sailing across oceans of cumulus, through which the Sahara reflected the rays of the sun, as if the desert were on fire. The scene was such that, were it faithfully portrayed on canvas, it would be rejected by the Royal Academy as preposterous impressionism.

But now I look down through the steady air of Mozambique—cloudless except for the odd fleck of cirrus way above in the tropopause—at olive-green jungle-covered slopes reaching up to the Muchinga Mountains of Northern Rhodesia. I see white smoke from numerous bush-fires—apparently routine—curling lazily upwards, and observe the sluggard Zambesi flowing yellow and muddy towards the Indian Ocean.

The view downwards through the Britannia's horizontal elliptical windows is excellent—as the picture at the top of page 139 (taken from the seated position) testifies.

Kentucky Airport, Salisbury—where we arrive after a four-hour, 305 m.p.h. cruise—is altogether appropriate to the prosperous, up-to-date nationhood of Southern Rhodesia. My eyes, narrowed by the actinic glare of acres of white pavement, note

G-ANBC, the third production Britannia 102, at Salisbury Airport.



(Left) Four - ringed conference at Nairobi (Capt. W. R. Hutcheson on the right). Note the new type of round - tipped D.H. solid alloy - bladed propeller, now being experimentally fitted to Britannias. Touching it on the right is Mr. Ross Hall of de Havilland Propellers.

The Britannia as seen from Salisbury's fine new control tower.

BRITANNIA DRESS REHEARSAL . . .

the pleasing proportions of the new terminal building, the modern surveillance radar mounted high on its slender concrete pillar, the businesslike fuss going on around a C.A.A. Viscount and a shiny well kept DC-3 of Hunting Clan's Africargo division. Dispersed over on the south side of the airport are Vampire Trainers and Dakotas of the Southern Rhodesian Air Force, sparkling silver and red in the sunshine.

Leaving us for 24 hours in the good hands of Paddy Aherne, B.O.A.C.'s Salisbury representative, our Britannia flies on to Johannesburg, terminus of the B.O.A.C. Springbok service. The 5,600-mile journey back to England, *via* the same sectors, is smooth, unflustered, comfortable. I had flown 40 hours in the Britannia, and in that time had developed an affection for the aeroplane which will, I venture, be shared by all who fly in her.

BRITANNIA 102 FLIGHT-PLANNING PROCEDURE

All transport aircraft today are operated to a rigid cruise-procedure, and none more so than those powered by turbines. The procedure evolved by B.O.A.C. for the Britannia owes much to their Comet I experience; in the course of adaptation it has become rather more complex, but no doubt it will become simplified and streamlined with experience. Certainly few of B.O.A.C.'s Britannia passengers would fail to be impressed by the care with which every sector of their flight was planned, whether or not they understood the technicalities.

There are two basic Britannia 102 cruise techniques: (1) "fast and level" and (2) "high-stepped," the first being a constant-height cruise at about 20,000ft, and the second a cruise which begins at this height and finishes—after 2,000ft stepped climbs every two hours—at about 30,000ft. The choice between these two techniques depends upon sector length—and to a lesser extent upon payload and winds. For sheer economy, of course, a climb cruise, *vide* the Comet I, would be best: but this is vitiated today by air traffic control quadrantal-separation considerations. In any case it is not, with the Britannia, sufficiently more economical than the "high-stepped" cruise to justify the extra attention it requires in flight.

Basis of the flight planning procedure for the Britannia is the Operations Manual, a document of tables and graphs devised by the B.O.A.C. Britannia Fleet and Operations Development Unit. From these the flight crew extract the fuel requirements by feeding in the five variables of payload to be lifted, sector length, winds, temperature, and altitude.

This is what has to be done between each sector.

(1) Knowing sector length, read off from the Ops. Manual "minimum sector fuel." This, simplified, comprises (a) normal flight fuel for take-off, climb, cruise, descent and landing; (b) normal reserves: six per cent of cruise fuel; fuel for diversion, and for holding and landing at the alternate airport; and 450 kg emergency reserve; (c) 315 kg of unusable fuel (this is likely to be reduced by changes to the tanks) and 225 kg for taxying. "Minimum sector fuel" can be exceeded, according to the flight plan, but never reduced.

(2) Check payload with traffic department.

(3) Ascertain zero fuel weight (which varies with basic operational weight) from this payload.

(4) Check the forecast winds with met.

(5) If winds exceed those allowed for in the minimum sector fuel—which they will do on 85 per cent of occasions—calculate fuel needed. Thus find *approximate* take-off weight.

(6) With this approximate weight enter special tables in the Ops. Manual and read off—very easily—the approximate height to fly, as near as possible, to V_{mo} (i.e., normal operating speed, or 235 kt for the Britannia 102) *without exceeding* it. (The never-exceed speed V_{ne} is 276 kt.) This ensures that cruising speed is as near to V_{mo} as possible without going too low and having to throttle—which is uneconomic.

(7) Having now got approximate weight and height to fly, and knowing *en route* temperature deviation, enter further Ops. Manual tables to find the T.A.S. and fuel-flows. Then calculate exact total flight fuel, and hence *exact* take-off weight. All the information necessary for a normal flight plan to be prepared has now been obtained.

The above procedure is for a typical "high-speed level" cruise. Other tables are provided in the Operations Manual for the economical long-distance "high-stepped" cruise; for a throttled cruise, should this be necessary; and for both three-engined and two-engined cruising. There is a table also showing fuel flows in the holding condition.

A "Howgozit" chart (of the kind pioneered by the Comet Fleet) is used in flight to keep a check of fuel remaining against distance-to-go.

TIMETABLE FOR THE BRITANNIA'S INAUGURAL "SPRINGBOK" SERVICE

To Johannesburg	BA115 Tuesdays		BA121 Fridays		BA115 Saturdays	
	GMT	*Local*	GMT	*Local*	GMT	*Local*
Dep. London	1200	*1200*	1200	*1200*	1200	*1200*
Arr. Rome	1520	*1620*	1520	*1620*	1520	*1620*
Dep. Rome	1605	*1705*	1605	*1705*	1605	*1705*
Arr. Khartoum ...	2310	*0110*	2310	*0110*	2310	*0110*
Dep. Khartoum ...	2355	*0155*	2355	*0155*	2355	*0155*
Arr. Nairobi	0405	*0705*	0405	*0705*	0405	*0705*
Dep. Nairobi	0450	*0750*	0450	*0750*	0450	*0750*
Arr. Salisbury	0855	*1055*	—	—	0855	*1055*
Dep. Salisbury	0940	*1140*	—	—	0940	*1140*
Arr. Johannesburg* ...	1150	*1350*	1050	*1250*	1150	*1350*

From Johannesburg	BA116 Mondays		BA116 Thursdays		BA122 Sundays	
	GMT	*Local*	GMT	*Local*	GMT	*Local*
Dep. Johannesburg ...	0915	*1115*	0915	*1115*	0915	*1115*
Arr. Salisbury	1130	*1330*	1130	*1330*	—	—
Dep. Salisbury	1215	*1415*	1215	*1415*	—	—
Arr. Nairobi	1630	*1930*	1630	*1930*	1515	*1815*
Dep. Nairobi	1715	*2015*	1715	*2015*	1600	*1900*
Arr. Khartoum ...	2125	*2325*	2125	*2325*	2010	*2210*
Dep. Khartoum ...	2210	*0010*	2210	*0010*	2055	*2255*
Arr. Rome	0545	*0645*	0545	*0645*	0430	*0530*
Dep. Rome	0630	*0730*	0630	*0730*	0515	*0615*
Arr. London*	1010	*1010*	1010	*1010*	0855	*0855*

*Arrival at Johannesburg and London on the following day.

BRITANNIA PROGRESS REPORT

The Background of Production and Development at Filton

THE entry of the Britannia into airline service provides a satisfying opportunity for surveying the pattern of progress at Bristol. Never before has a transport aircraft on the threshold of service been so exhaustively tested, or so thoroughly proved. And it is unusual for an airliner to enter service with production of the series complete, modified to a late standard, and with larger successors already flying.

In terms of developed manufacturing techniques, fatigue and structural testing, service and overhaul knowledge—factors in which there is hardly any substitute for experience—Bristol are able to offer to the airlines a new airframe and a new engine which have been developed to a standard usually associated with several years of airline experience. Associated with this background are the expanding facilities that have been set up for Britannia and Proteus servicing and a training school for instruction in maintenance and servicing. It would be hard to imagine a more propitious beginning.

To discuss these aspects of Britannia progress and to find out something more of the development programmes and future thinking at both the Bristol Aircraft and Engine companies, *Flight* recently visited Filton—on a deteriorating January day that kept the staff Gemini confined to its hangar.

From Mr. Peter Masefield, managing director of Bristol Aircraft, Ltd., we learnt something of his company's planning for the years ahead. Bristol have recently formed an active market study group to assess the future trends of air traffic and to review the market that will be available to the Britannia or its successors. One of their studies—an assessment of the capacity that will be required to accommodate world traffic in the 1960s—is of particular interest, as it was just this fascinating (if slippery) terrain which *Flight* surveyed in Part I of its examination of traffic and transports in 1962—"The Hungry Airlines" (*Flight*, November 23).

It was apparent from the graph of the Bristol analysis that, in the region where the ordinates of the two curves are comparable, the results are roughly the same. Both show that a substantial world market exists for additional aircraft in the 1960s. But although the conclusions of these studies are similar, the basic assumptions are by no means so. Bristol have, in our view, been pessimistic in assuming a traffic rise of only ten per cent per year; pessimistic because the average annual increase since 1948 has been 16.6 per cent and there seems little reason to forecast a decline.

But allowing for the cautious estimate—and this traffic growth guessing-game is played in deadly earnest by every manufacturer—it was interesting to see that the balance had been swung in favour of similar totals by Bristol's estimate for the rate of attrition of present piston-engined fleets. "As soon as passengers get acquainted with the joys of turbine-transport travel," explained Mr. Masefield, "load-factors on piston-engined aircraft will fall off." And this, he expected, would happen quite rapidly from 1960 when the "turbine age" begins. The Bristol estimate of this vitally important and hard-to-predict factor of piston-engine fleet decline in assessing the market situation a few years ahead is lent significance by the frequency with which *Flight* has been taken to task for *over-estimating* (a reduction of 48 per cent by 1962) the rate at which present fleets will be written off.

Another intriguing market survey curve was one that had been drawn on a "supposing all the aeroplanes in the world . . ." basis. It showed an estimate of the number of Britannias that would be required if they could be exclusively sold on every route for which they are suitable; and Britannia flexibility is such that this represents a very large total indeed. "They won't *all* be Britannias, of course," said Mr. Masefield; but it is interesting to muse upon the unconfined and confident thinking that provoked this analysis. "We believe in the turboprop," he emphasized, and he went on to predict an upsurge of turboprop interest among the airlines when the Britannia goes into service.

Although Bristol are wide awake to the possibility of a rapidly-developing market for in-service-in-1965 medium jets, it is to developments of the Britannia that they feel the airlines should look for the richest economic rewards. The airframe has plenty of

The centre bay of the Britannia Assembly Hall. In the foreground is the first 313 for El Al; beyond it a 312 for B.O.A.C.—both due for delivery in May. In the left background is B.O.A.C.'s fifteenth and last 102.

BRITANNIA PROGRESS REPORT . . .

development potential still available. A new Britannia version, to be known as the 420—with a further stretched fuselage, powered by four Orions and with a cruising speed of 440 m.p.h.—should be *available* in 1959. And Bristol are still considering an even faster thin-wing Britannia as an active project to follow on the heels of the 420.

But although future projects are being actively studied, the Britannia 100 is still the main concern of much of the Bristol organization. Some of the arrangements that are being made for Britannia servicing and maintenance training were explained to us by Mr. Wearen, personal assistant to the general services manager. The company are rightly very proud of their newly completed servicing school housed in the quiet and spacious demonstration hall. Among the instructional rigs is a skeleton cockpit trainer. This is a truly accessible fuselage-nose functional rig incorporating all the cockpit systems, but laid bare for the controls above the floor, and the runs and components below, to be studied and operated in comfort. Provision has been made in the layout for snags to be introduced artificially as part of the programme for ground engineers under training.

Another fuselage nose—but in this case completely equipped (it is in fact the nose of G-ALRX, which was salvaged from the Severn Estuary)—is on the other side of the demonstration hall. Although many of the controls and instruments are dummies, detailed representation of all the cockpit and galley systems can be used for familiarization and procedure training.

Several technicians from El Al are undergoing instruction in the school (photograph p. 147); afterwards they will return to instruct their own crews on Britannia maintenance. The same procedure would probably be followed by Northeast Airlines, although the North American operators can turn to the expanding overhaul organization in Canada which is under the general supervision of the Bristol Aeroplane Co. of Canada (1956), Ltd. Northeast, however, could be expected to ask for a team of at least four Bristol maintenance engineers when the first of their Britannia 305s are delivered.

Bristol service will be available all round the world as Britannia routes open up. For the start of B.O.A.C.'s Johannesburg and Far Eastern routes, a service team—consisting of two airframe men and two electricians—will be posted at London Airport and one- or two-man "teams" will be stationed at Johannesburg, Karachi, Singapore, Hong Kong and Entebbe.

Mr. Wearen expressed the greatest satisfaction with the aircraft structure, which was standing up to its job admirably; and component reliability—aimed at a general overhaul life of 3,000 hr—is being worked up to some very good totals, although it could not yet be said that all the many ancillary components have reached their ultimate extended reliability. The route-proving flights have shown up one or two snags, but these mostly indicated that minor modifications were required to improve passenger comfort. On recent flights, mechanical troubles had been very few; Britannia 100 Baker Jig's American trip in August—"Operation Clockwork"—was witness to that.

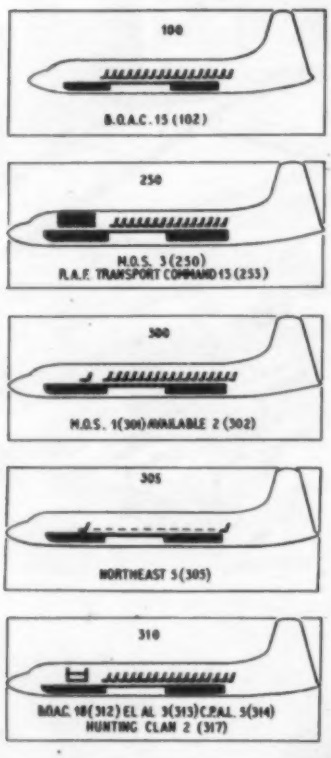
On the steep hill between the runway level of the servicing school and the Aircraft Company buildings, two Britannia 310 fuselages are under test—one in the structural test rig on the hillside, and another (complete with inboard wings and nacelles) being pressure tested in the water tank at the bottom. (A Britannia 100 has now undergone well over 50,000 simulated hours of fatigue testing in the tank at the R.A.E., Farnborough.)

Also at "ground level" is the Britannia erecting hall. Here, in the first-stage jigs, the rear fuselages of 310s are each prominently placarded with the scheduled completion date and customer's name. Stage-by-stage programming is a very prominent feature of Britannia assembly—every jig, every fuselage and every aircraft has the target date displayed where it can be clearly seen by everyone in the shop, and as these dates have been realistically chosen, it has become—as was intended—a point of honour to make delivery on time. The next step will be the bold inclusion, at each operational stage, of a target time-of-day as well as a date.

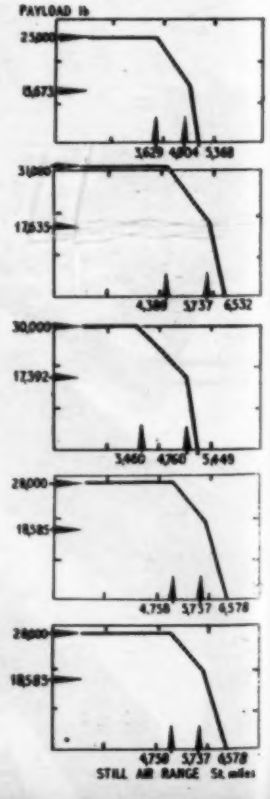
In the fuselage sub-assembly stage the maximum possible amount of ducting and internal equipment is fitted; with the result that, at first glance, incomplete centre sections and tail cones tend to appear to be in a state of disassembly. But this is a technique which must save considerable time in final assembly, when the nearly complete aircraft occupies so much more valuable space.

The fine finish on all Britannia surfaces is achieved by a high standard of production skill and by unusual care in the protection of the skins, both by Bristol and by Blackburn and General Aircraft, to whom the fuselage centre-section and all the skin panels are subcontracted. The familiar pale blue plastic covering is applied at the individual panel stage and application is repeated after spin-dimpling—by a rotary dimpling press—has been performed on the rivet holes. It is worth remarking that stacked skin panels are also invariably separated by additional inter-layer packing. At the completion of the fuselage sub-

***BRITANNIA AIDE-MEMOIRE:** Payload-range curves and orders for each mark of Britannia. The Series 305 has been included because—apart from having bag tanks—it is similar to the Mark 310. The seating arrangements for Northeast have yet to be finalized; the 310 is shown with crew rest bunks. All aircraft have underfloor cargo capacity.*



Gross wt. (lb)	Powerplant	Max. fuel (Imp. gal)	Mean cruise speed (m.p.h.)	Length ft in
155,000	Proteus 705 3,900 e.h.p.	6,688	367	114 0
175,000	Proteus 755 4,120 e.h.p.	8,486	391	124 3
160,000	Proteus 755 4,120 e.h.p.	6,688	391	124 3
175,000	Proteus 755 4,120 e.h.p.	8,486	391	124 3
175,000	Proteus 755 4,120 e.h.p.	8,486	391	124 3



Britannia 102—a new look and a new sound on B.O.A.C. routes.

assembly stage a further—and much coarser—silver-coloured plastic skin is added which will withstand the occasional rough handling experienced in final assembly and inter-shop transfer.

The lofty Britannia assembly hall is the scene of the final stages of construction. In spite of the size of the hangar, its three-cell layout with great intermediate supporting stanchions imposes a restriction upon unhindered flow from stage to stage; and progress from one bay to an adjacent one must be *via* the huge electrically operated hangar doors.

Arranged with neat symmetry in the centre bay is an impressive array of Britannias. Among them are El Al's three 313s (the first nearly complete, the others still in jigs), B.O.A.C.'s second 312 and (looking little the worse for wear) Baker Jig, the aircraft which was demonstrated in America. (All Britannias—even incomplete ones—are referred to by their registration letters in terms of the old phonetic alphabet.)

The most intensive activity in the great hall was centred around five Britannia 100s (Nos. 9, 12, 13, 14 and 15), the deadline placard upon each of which carried the words "Operation Gauntlet." "Gauntlet" is the code name for an urgent Bristol programme designed to extract the utmost benefit (and incidentally to pass it on to B.O.A.C.) from the extra time which became available while a solution was sought for the dry-icing troubles. Its intention is to bring the 100s up to the latest modification standard that can be incorporated without causing any delivery set-back on this account—and to reach a very late standard in the continuous modification process. Six Britannia 100s have been delivered to B.O.A.C., and two more are undergoing final modification away from Filton: one is at Weston and the other at Short Bros. and Harland, Ltd. The next aircraft to be delivered is No. 9; No. 10 is Baker Jig and—like No. 11—is undergoing engine modifications.

Bristol effort is also concentrated on the production of Britannias for B.O.A.C. and El Al: the second 312 is scheduled to fly in mid-April and the first 313 later that month. A further 28 aircraft (the Britannia order book stands at 65) are being built by Short Bros. and Harland at Belfast—sixteen 250s for the Ministry of Supply (3) and the R.A.F. (13); five 314s for C.P.A.L.; five 305s (released by B.O.A.C.) for Northeast; and two 300-series aircraft.

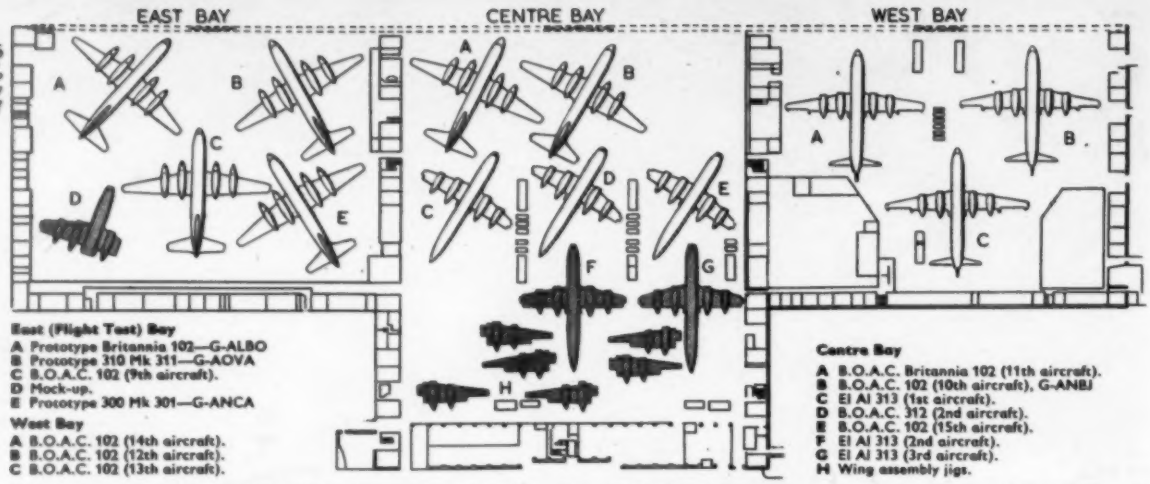
The easterly bay of the assembly hall houses aircraft which are undergoing development: G-ALBO, the prototype 100 equipped with an icing sprayrig; Victor Able, the first B.O.A.C. 312 (painted in Bristol colours and designated 311), and G-ANCA, the first Britannia 300, which has been used for most of the certification testing for the long-range 310s.

Victor Able, which on the afternoon of *Flight*'s visit had just completed its first take-off at all-up weight—actually 175,098 lb—is undergoing A.R.B. certification trials; but only those—winterization and fuel system testing—that have not already been undertaken on the similar (but less adequately tanked) series 300. When these are complete, the aircraft will be delivered to B.O.A.C.; in fact, the Corporation's blue and cream coloured walls and blue seats were just visible in a fuselage crammed with test equipment.

A new building at Bristol houses a specialist team which has been built up to study various interiors and—as in the case of Northeast—to co-operate with the airlines in achieving the most eye-appealing, yet restful colour schemes: an aspect of design which is rapidly growing in commercial importance.

Details of Northeast's interior are still largely under the airline's security-cloak, but we gathered that it would be "striking," and that the step-down compartment adjacent to the rear pressure bulkhead (occupied by toilets in B.O.A.C. aircraft) would be adapted as a lounge. The wisdom of this seems obvious.

Regardless of the scale of production effort that is mounted behind a transport aircraft, the proof of the operational pudding


EAST BAY
CENTRE BAY
WEST BAY
East (Flight Test) Bay
A Prototype Britannia 102—G-ALBO
B Prototype 310 Mk 311—G-AOVA
C B.O.A.C. 102 (9th aircraft).
D Mock-up.
E Prototype 300 Mk 301—G-ANCA
West Bay
A B.O.A.C. 102 (14th aircraft).
B B.O.A.C. 102 (12th aircraft).
C B.O.A.C. 102 (13th aircraft).
Centre Bay
A B.O.A.C. Britannia 102 (11th aircraft).
B B.O.A.C. 102 (10th aircraft), G-ANBJ
C El Al 313 (1st aircraft).
D B.O.A.C. 312 (2nd aircraft).
E B.O.A.C. 102 (15th aircraft).
F El Al 313 (2nd aircraft).
G El Al 313 (3rd aircraft).
H Wing assembly jigs.

Under the one great roof of the Britannia assembly hall construction of the aircraft proceeds from jig stages (shown in tone) through final assembly and painting in the West Bay, to flight test from the East Bay. This revealing drawing shows pictorially the complete Britannia production position as at mid-January this year.

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is to be found in long hours of flying under the widest variety of weather conditions over airline routes, keeping to airline schedules. Britannia flying has now reached the truly massive total of 8,000 hr, of which half has been accumulated by Bristol's flight test crews. There has been an erroneous impression that, in the past few months, Britannias have been "sitting around doing nothing." This could hardly be farther from the truth. Not only have the aircraft been in constant use, but they have flown millions of revenue-earning passenger miles on trooping and evacuation flights. Typical of these sorties was the carriage of 99 troops to Aden, returning with 110-plus evacuees from Bahrein; while it is reported that on one occasion during the Hungarian airlift 196 refugees were transported in a Britannia.

A considerable amount of flying was also done while the test crews were searching for dry ice: in seven trips to Entebbe, Baker How flew 500 hr in order to spend 40 hr under the inter-tropical front conditions in which dry ice is generated. For performance checking under tropical conditions many flights have been made to Idris, in North Africa. Baker Able was used for Britannia 100 tropical trials (which were completed in March 1955) and was then used as a Proteus 755 test bed; and Charlie Able finished similar trials for the 301 last November. Perhaps the latest—and most impressive—test is the 13-hour flight with the first 312 (see *Flight*, January 18), made as a preliminary operational and navigational trial for the trip to Vancouver for winterization trials. It was due to take place this week with pilots of El Al on board.

Such flights have formed the pattern of flying by the Bristol test team. Five crews under Walter Gibb, Bristol's chief test pilot, and Tommy Farnsworth, the development test pilot, are trained up to airline operational standards and they can—and do—fly "round-the-clock." Filton has been made highly operational by the installation of radar and visual aids; during periods of intensive flying landings have been made with a cloud-base of only 200ft.

As a result of this unprecedented flight-test effort, B.O.A.C. has been relieved of a good deal of the development flying that is customary if an aircraft is delivered prior to its grant of a C. of A. Instead, the Corporation has been able to concentrate on proving flights and crew training, so that on both sides a mammoth pre-service experience has been gained. Both airline and Bristol pilots have made many long flights. In the words of Walter Gibb: "Two hours—that's a hop round the houses; five hours is normal; eight so-so; ten to 12 hours not unusual." After going from Filton to Malta, Tripoli, Tunis and back to Filton there is still an hour to spare—usually occupied by flying to Cornwall. On a six-hour flight the Britannia flies around England twice. "But the beauty of it is," added W/C. Gibb, "that while on a piston-engined airliner you have 96 or so big hammers thumping up and down umpteen times a minute, and 24 hours later—long after the flight is completed—you can still hear them, I've done 23 almost continuous hours in the Britannia without being exhausted."

The Britannia's introduction to world air routes will begin with three services a week to Johannesburg. To suit Air Traffic Control requirements, which mitigate against a true "cruise-climb," a stepped climb procedure between heights of 20,000 and 30,000ft (the operational ceiling is 36,000ft) will be used by B.O.A.C. A fuller account of the operational procedure used is given on page 142, but it is of interest to record here that the cruising Mach number for the Britannia 100 has been established as ranging between 0.44 and 0.54 as height is gained in the cruise-climb, with a maximum cruising Mach number of 0.57—although M=0.7 has been recorded on a test flight.

The Britannia has reached service with B.O.A.C. after a period of disappointing delays, but now has a background of experience and an expectation of reliability for which the airline business knows no parallel. It would be easy for Bristol to look back at the prodigious efforts that have been made to cure the dry ice troubles, the challenge of "Operation Gauntlet," increasing production of the long-range versions, and the many hours spent airborne over Europe and Africa, and to feel that reaching this stage was a job well done. But rather there is a feeling that the company are only on the threshold of the great stage in Britannia history. "Just wait," they have occasionally said, "until the Britannia is in service." And now that day has arrived. A.T.P.

B.O.A.C.'s BRITANNIA PLANS

By the autumn of this year B.O.A.C.'s 15 Britannia 102s will have taken over the major part of the work now being done by the Corporation's Argonauts and Constellation 749As.

The thrice-weekly mixed-class Britannia service to Johannesburg which starts today, February 1, will displace 749A services entirely, leaving Argonauts to do the East African services ter-

The scene in the centre bay of the Assembly Hall. The diagram above is contemporary with this photograph and enables each aircraft to be identified.

First air-to-air picture of the Britannia 311. After certification tests this aircraft—G-AOVA— will be delivered to B.O.A.C. as a 312.

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minating at Dar-es-Salaam and Nairobi, and to back up Stratocruisers on the West African run.

The thrice-weekly Britannia service to Sydney, which is due to start on March 2, will displace the 749As on this route also; and the progressive introduction of Britannias on the Corporation's other Far Eastern services will, by the autumn, have entirely displaced the Argonauts and 749As on those routes. The Britannia will start to serve the route to Tokyo on July 16, and it will be operating to Colombo and Singapore by mid-September. The only non-Britannia B.O.A.C. services to the east will be those terminating at Bahrein and Karachi: these will be flown by 749As.

The future of the 21 Argonauts and the 16 749As is thus uncertain; but it seems probab.e that if their disposal is being considered the 749As will be sold first, and that they will be required to be sold—as they were bought—for dollars.

Delivery by Bristol of the first of B.O.A.C.'s 18* long-range Britannia 312s is scheduled for May 9, but the date of its introduction by B.O.A.C. into Atlantic service is as yet uncertain. The main reason for this is that B.O.A.C. are up against a weighty crew-training problem. Atlantic crews are still being converted to DC-7Cs, and this training programme will continue until the summer.

It remains to be seen whether El Al, who are due to receive the first of their three long-range (313) Britannias only a few days after B.O.A.C.—actually on May 14—will introduce the long-range Britannia on to the Atlantic before B.O.A.C. It seems likely that neither B.O.A.C. nor El Al will want to be scooped by the other in offering the world's first turbine services across the Atlantic.

Crew-training is, incidentally, likely to remain one of B.O.A.C.'s biggest problems between now and 1960. During that time the Corporation will have introduced five new types of aircraft—Britannia 102, DC-7C, Britannia 312, Comet 4, and Boeing 707.

The inaugural Britannia 102 "Springbok" service will operate from London to Johannesburg *via* Rome, Khartoum, Nairobi (Entebbe in the rainy season), and Salisbury. It will be thrice-weekly, omitting Salisbury on one service a week. Elapsed time on the London to Johannesburg route (overflying Salisbury) is 22 hr 50 min; the comparable elapsed time for the DC-7B operated by S.A.A. in pool with B.O.A.C. is 23 hours. The full Britannia timetable is reproduced on page 142.

The spacious, well lit Demonstration Hall at Filton is here the scene of an instrumentation instruction class for mechanics of El Al. The intruding nose in the background is that of Britannia G-ALRX, now used as a crew training mock-up.

**A further seven long-range 312s have been ordered to replace the five 305s sold by Bristol to Northeast, and the two short-range 302s, which are as yet uncommitted.*

POWER FOR THE BRITANNIA

THE powerplant is a key factor in any transport, and it can determine an airliner's success or failure. Bristol's great commercial venture has grown up around the company's own Proteus which, after a lengthy but steady gestatory period, has emerged as the first large turboprop in the world to enter airline service. *Flight* published a full description of the Proteus 705, powerplant of the Britannia 102, on July 6, 1952; further notes on the 705 and the 755 (the engine of the later Britannias) were contained in our issue of August 12, 1955. In this issue it is desirable to bring the engine picture up-to-date.

Overshadowing all other factors in recent Proteus history is the problem which has been posed by engine icing of an unusual form. By the end of 1955 both the Britannia 102 and the Proteus 705 had been given a clean bill of health by the A.R.B. and production aeroplanes had flown many hundreds of hours on crew-training and route-proving. The powerplant, in particular, had been most thoroughly proved. Its excellent protection against icing had been exhaustively investigated—and not found wanting—in an arduous programme of trials. Proteus engines mounted in an Ambassador had been subjected to every type of icing hitherto known, while TV cameras recorded the conditions inside the powerplant (as described in our issue of September 9, 1955). The Proteus was in fact the only turbine engine cleared for unlimited operation in icing conditions.

In his own masterly manner Capt. Houston relates on p. 136 exactly what form the new trouble took. It comprised sudden extinction of the flame in one or more combustion chambers, and on certain occasions resulted in complete loss of power in two of the four engines simultaneously. At no time, however, did the phenomenon cause loss of altitude. The incidents were reported in conditions in which no airframe icing was present, apart from a thin white "witness line" along the null point on the airframe leading edges.

Retrospectively, it is not difficult to appreciate that such occurrences were baffling in the extreme. They were of a kind which has great popular interest, so that many people began to propound panaceas even without being in possession of all available data. The Bristol Aeroplane Company sent a Britannia to Entebbe within a few weeks of B.O.A.C.'s experiencing the trouble, and this confirmed the hypothesis that the phenomenon was due to icing, and to icing of a new form, namely, dry ice crystals. This aircraft was extensively instrumented to measure atmospheric conditions, and carried television equipment for the study of conditions in the powerplant.

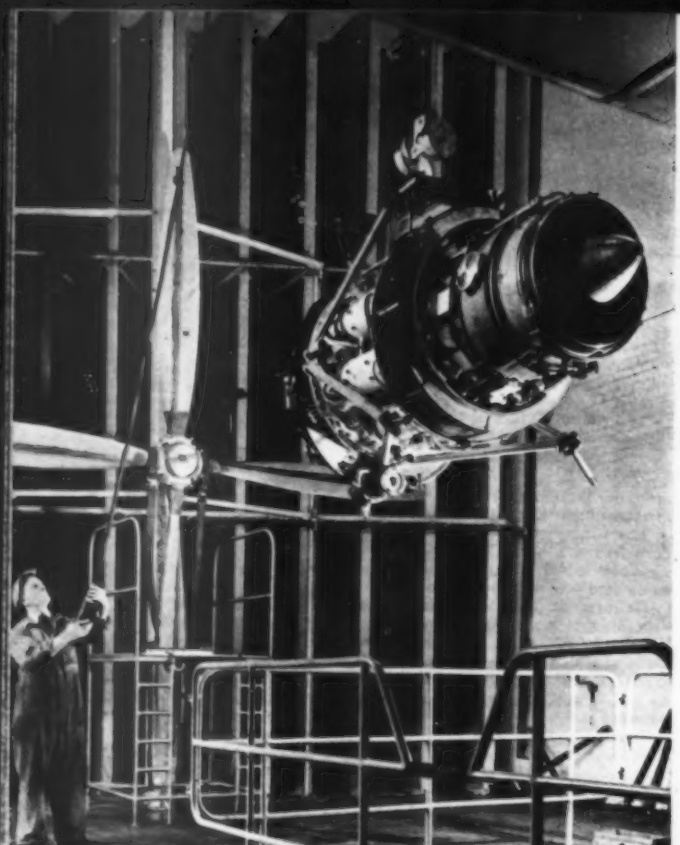
The initial difficulty in diagnosing the cause of the trouble was that very high concentrations of dry ice crystals are often visible only as a thin wispy cloud. A thick industrial fog contains perhaps 0.1 gm of water per cubic metre and heavy snow contains about 1 gm. During the Britannia's A.R.B. flying the Proteus was found capable of handling the very severe supercooled water content of 2 gm/cu m for a mile and a half (about 20 sec); but the great cu-nim cloud build-ups of the inter-tropical front (such as are met over Africa) can hold as much as 6 gm/cu m of ice crystals—and over distances very much greater than a mile and a half. Surprisingly (on first consideration), the greater size of the crystals renders such a high concentration all but invisible.

The crystals would not adhere to the airframe, but they would stick to the warm structures crossing the intake of the Proteus and there build up a snowball accretion on the stagnation points. These accretions would then break free and enter the engine as a solid mass of slush. Capt. Houston comments on the excellent dousing properties of such a mixture, and of its ability to blank off the airflow.

Once the giant had been nailed he was no longer a giant, but merely another complex technical problem for which a solution could be found.

[*Continued overleaf*

Developed by Smiths-K.L.G., the glow-plug used in the Proteus consists of a platinum-rhodium alloy tube thermally insulated from the body of the plug.



Bristol Aero-Engines are extremely well provided in the matter of test-facilities for gas turbines. Here a production Proteus 705 comes off the bed after its acceptance run.

POWER FOR THE BRITANNIA . . .

Cold baffles over the structures crossing the intake stopped the build-up of ice and slush, and glow-plugs (see previous page and p. 136) were introduced as a second line of defence to ensure a positive and instantaneous relight. During the extensive proving of the modified engines Britannias made numerous trips to Entebbe in Uganda, whence flight trials were carried out under the optimum conditions for this type of ice crystal concentration in cumulo-nimbus clouds. Cathode-ray flame-detectors were used over Africa to establish the behaviour of combustion. Invariably the glow-plug would relight the fuel immediately and the loss of full power was never greater than a second. The re-light was barely detectable except by noting a transient drop in r.p.m. from 60 to 300 in about 11,000 r.p.m.

With cold baffles over the structure crossing the intake there was no accretion and no need for any remedial measures. Full heating systems have, of course, been retained to meet normal icing conditions. Suffice to say that the Proteus can now meet with equanimity all atmospheric conditions—including those never before encountered by transport aircraft.

Excluding icing damage during the fierce and deliberate trials described, B.O.A.C. have had to "pull" only five powerplants during their first 15,800 engine hours of operation, and three of these occasions were attributable to accessory failures. Britannias have now flown in every type of climate, topography and weather, and their reliability has been quite extraordinary.

Proteus 705s are at present cleared for 500 hours between overhauls and several engines are doing trials for 650 hr, which is an excellent figure for an engine just entering scheduled passenger service. The more powerful Proteus 755 promises to have an equally good time between overhauls. On the 705, Check 1 is currently going up from 75 hr to 100 hr, and it should reach 200 hr on passenger routes. An intermediate superficial examination for leaks will be made at 100 hr.

A startling result of these figures is that B.O.A.C. are now scheduling Britannias on tremendously lengthy operations—two round trips to Johannesburg or one to Sydney—without opening the cowlings. Even oil trucks are spurned; the Johannesburg oilers are now resigned to the fact that their services are not needed. A quantitative consumption figure is provided by the North American tour of the tenth production machine, in which only 11 gal of oil were consumed (per airc aft) in 90 hours' intensive demonstration flying. Light-grade mineral oil is used, although the 755-series engine will employ a synthetic oil. B.O.A.C. burn kerosine in the Britannia. The Proteus is, however, cleared on wide-cut, and the Marine Proteus is at present engaged upon 1,000-hour runs on a light diesel oil.

There remains to be discussed the much more powerful Orion. This advanced split-compressor unit was exclusively described in *Flight* for October 26 last, and its progress has so far been extremely encouraging. In many of the most important respects the Orion makes use of design techniques or components already extensively developed and proved by a long period of running. The double-helical reduction gear, for example, is based closely on that of the Proteus, and has already completed many thousands of hours' running (driven by coupled Proteus engines) at from 4,000 to 5,750 shaft horse-power.

As the Orion was designed when *all* the Britannia requirements were known, in Bristol's opinion it should be the ideal powerplant for such an aircraft. Not only does it provide very high cruise power at altitude and constant maximum power under all conditions of airfield height and temperature, but its peak temperatures have been set at so modest a level as to ensure a very long life, and it is hoped to work up to a 2,000-hr overhaul period fairly rapidly. The first Britannia ever built, G-ALBO, has been flying with an Orion in the No. 1 position since last summer, and will soon receive a second Orion in the corresponding position on the starboard side. It is probable that the first 301, G-ANCA, will be converted to four-Orion power towards the end of this year. Conversion is a comparatively minor job, requiring a direct switch of engine-change units and minor structural alterations to accommodate the fatter tailpipe, shroud and fairing. Each Orion is built as a complete powerplant, with its own integral oil system, cowling and propeller. At present the standard de Havilland 16ft hollow-steel-blade propeller of the Proteus is also being employed on the more powerful engine.

Well over 1,100 hr has now been run on Orions, including non-stop evaluations exceeding 100 hr. Flight and bench trials have definitely established that (as was described on October 26) the engine is inherently surge-free, irrespective of what the pilot may do. Although single-lever control is possible, the installation in G-ALBO provides for independent variation of power and r.p.m.

CONTRIBUTORS TO THE BRITANNIA

THE following is a list, provided by Bristol Aircraft, Ltd., of numerous firms and the materials or parts they have supplied for the construction and equipment of the Britannia. It is continued together with an additional list on page 149.

AIRFRAME

Metal Supplies.—Accles and Pollock, Ltd., steel tubes; Aluminium Die Castings, Ltd., light-alloy castings; Birmetals, Ltd., sheet, bar, tube and sections; Birmingham Aluminium Casting (1903) Co., Ltd., light-alloy and magnesium castings; James Booth and Co., Ltd., light-alloy bar and tube; Brett's Stamping Co., Ltd., steel and light-alloy forgings; The Britannia Tube Co., Ltd., light-alloy bar and tube; British Aluminium Co., Ltd., light-alloy bar and tube; Brown Bayley Steels, Ltd., steel bar.

C. G. Carlisle and Co., Ltd., stainless-steel bar; Clyde Alloy Steel Co., Ltd., steel bar; Deritend Stamping Co., Ltd., steel and light-alloy forgings; Dudley Drop Forgings, Ltd., steel forgings; English Steel Corporation, Ltd., steel bar and forgings; Exors. of James Mills, Ltd., steel bar; Thos. Firth and John Brown, Ltd., steel bar; Firth Vickers Stainless Steels, Ltd., stainless-steel sheet and bar; Govan Shafting and Engineering Co., Ltd., steel bar; High Duty Alloys, Ltd., light-alloy castings, forgings and extruded sections; Hughes-Johnson Stampings, Ltd., steel forgings; Imperial Chemical Industries, Ltd., light-alloy bar and tube.

E. and E. Kaye, Ltd., light-alloy bar and tube; J. H. Lavender and Co., Ltd., light-alloy castings; Light-Metal Forgings, Ltd., light-alloy forgings; H. J. Maybrey and Co., Ltd., light-alloy castings; Northern Aluminium Co., Ltd., light-alloy sheet, bar, extruded sections, forgings, and castings; Perry Barr Metal Co., Ltd., light-alloy castings; Premier Aluminium Co., Ltd., light-alloy castings; Reynolds Tube Co., Ltd., steel tubes; Sterling Metals, Ltd., light-alloy and magnesium castings; J. Stone and Co., Ltd., magnesium castings; T. I. Aluminium, Ltd., light-alloy bar and tube; Vaughan Bros. (Drop Forgings), Ltd., steel forgings; Wednesbury Stampings, Ltd., light-alloy forgings.

Components, Equipment, Details and Materials.—Aerolex, Ltd., buckles; B. Attewell and Sons, Ltd., shims; Avery-Hardoll, Ltd., refuelling couplings; Avica Equipment, Ltd., assemblies; Avimo, Ltd., couplings, pressure heads; Automotive Engineers, Ltd., hydraulic units; Barnet Instruments, Ltd., pressure gauges; Barron and Shepherd, Ltd., ground equipment; Belling and Lee, Ltd., switches and fuse holders; Bell's Asbestos and Engineering, Ltd., sleeves, etc.; D. H. Bonella, Ltd., terminal blocks and sockets; Thomas Boorn and Co., Ltd., hose; Bowden (Engineers), Ltd., cables, clips; British Messier, Ltd., undercarriage, hydraulics; British Overseas Airways Corporation, refuelling couplings; British Thomson-Houston Co., Ltd., switches, contactors, circuit breakers; British Wire Products, Ltd., cables; Brown Brothers (Aircraft), Ltd., grommets; Burgess Products Co., Ltd., actuators.

Carr Fastener Co., Ltd., studs, eyelets, dot buttons; Cathodeon, Ltd., crash switches; Ceag, Ltd., filaments; Clarke Chapman and Co., Ltd., mirrors; Charles Churchill and Co., Ltd., unbrake screws; Crabtree, Ltd., electrical sockets, etc.; Craigpark Electric Cables Co., Ltd., cables; Dart Spring Co., Ltd., springs and clips; de Havilland Propellers, Ltd., propellers; Dowty Equipment, Ltd., switches, indicators, selector valves; Dunlop Rubber Co., Ltd., flexible pipes, wheels and brakes, rubber; Ekco Electronics, Ltd., search radar equipment; Engineering and Lighting Equipment Co., Ltd., fuse carriers; Erectors, Ltd., ground equipment.

Ferodo, Ltd., Ferodo materials, Ferrobestos; Fibreglass, Ltd., Fibreglass; Fireproof Tanks, Ltd., fuel bags; T. F. Firth and Sons, Ltd.,

Nose sections of B.O.A.C.'s Britannia 310s coming out of the jigs.

CONTRIBUTORS TO THE BRITANNIA...

carpets; Flexo Plywood Industries, Ltd., furnishings; Flight Refuelling, Ltd., pipe connections, valves; The General Electric Co., Ltd., fans, reading lamps, water heaters, ovens, humidifiers; Sir George Godfrey and Partners, Ltd., air conditioning; Graviner Manufacturing Co., Ltd., fire extinguishers; The Hairlok Co., Ltd., cushions; John Hall, Ltd., key rings; Hall and Hall, Ltd., rubber; Harley Aircraft Landing Lamps, landing lamps; Thos. P. Headland, Ltd., fasteners, grommets, springs; Hellermann, Ltd., plugs, bungs, sleeves; High Pressure Components, Ltd., split collars; Marcus H. Hodges and Sons (Engineers), Ltd., ground equipment.

Imperial Chemical Industries, Ltd., plastics; India Rubber Gutta Percha Co., rubber extrusions; Ironside Engineering Co., Ltd., ground equipment; Johnson and Phillips, Ltd., suppressors; Kellett Woodman and Co., wool; Kelston Engineering Co., Ltd., ground equipment; King Aircraft Corpn., fasteners, straps; Laidlow and Ettrup, Ltd., circuit breakers; Latex Upholstery, Ltd., cushions, etc.; Leathercloth Co., Ltd., fabric; Luxram Electric, Ltd., filament; William Mallinson and Co., Ltd., panels; Marconi's Wireless Telegraph Co., Ltd., radio equipment; Marston Excelsior, Ltd., air-conditioning coolers; Midland Aeroquipment, Ltd., door locks; Mills Equipment Co., Ltd., shoulder harness; Mollart Engineering Co., Ltd., universal joints; Harold Moore and Sons, Ltd., plastics; Moulded Components (Jablo), Ltd., Aerojablex.

Negretti and Zambra, Ltd., pressure indicators; Normalair, Ltd., air conditioning; Norstel, Ltd., ground equipment; Northern Rubber Co., Ltd., rubber mouldings and extrusion; Oddie, Bradbury and Cull, Ltd., fasteners; Old Bleach Linen Co., Ltd., curtains; Partridge Transformers, Ltd., transformers; Peradin and Watercraft, Ltd., rubber parts; Phillips Electrical, Ltd., lamps, valves; Pianoforte Supplies, Ltd., hinges; Plessey Co., Ltd., sockets, plugs, fuse holders; R. B. Pullin and Co., Ltd., switches, relays; Pulsometer Engineering Co., Ltd., toilet pumps; Pyrene, Ltd., extinguishers, smoke detectors.

Redifon, Ltd., public-address system; Renown Springs, Ltd., springs and clips; Rotax, Ltd., electrical systems; Rotol, Ltd., gearboxes; Geo. Salter and Co., Ltd., springs and clips; Sangamo Weston, Ltd., instruments; Saunders Valve Co., Ltd., cocks and valves, especially water system; Self-Priming Pump and Engineeering Co., Ltd., pumps, non-return valves; Siebe Gorman and Co., Ltd., cylinders, filters; Simmonds Aerocessories, Ltd., Pacitor gauge equipment; Skeldings, Ltd., springs and clips; Smiths Aircraft Instruments, Ltd., autopilot and instruments; Spaulings, Ltd., plastic mouldings; George Spencer Moulton and Co., Ltd., rubber; Sperry Gyroscope Co., Ltd., artificial horizon, gyro compass; Standard Telephones and Cables, Ltd., wireless.

Taskers, Ltd., ground equipment; Tecalemit, Ltd., adaptors, lubricating equipment; Teddington Aircraft Controls, Ltd., air conditioning control equipment; Teleflex Products, Ltd., remote-control mechanism; Telegraph Condenser Co., Ltd., capacitors; Tenaplas, Ltd., plastic mouldings; Herbert Terry and Sons, Ltd., clips; Thermal Control Co., Ltd., control units; Thermo-Plastics, Ltd., glasscloth; Thorn Electrical Industries, Ltd., filaments, lamps; Ronald Trist and Co., Ltd., rubber sealing rings, etc.

Ultra Electric, Ltd., throttle controls, intercom; Varley Dry Accumulators, Ltd., batteries; Vickers-Armstrongs (Aircraft), Ltd., cocks and seats; James Walker and Co., Ltd., washers, sealing rings, etc.; Wallington, Weston and Co., Ltd., rubber seals, etc.; West Bromwich Spring Co., Ltd., springs; Westinghouse Brake and Signal Co., Ltd., rectifiers; Whitby and Chandler, Ltd., rubber mouldings; W. H. Wilcox and Co., Ltd., universal joints; W. J. Wild, Ltd., shims; Wilkinson Rubber Linatex, Ltd., rubber sealing strip and seals.

ENGINES

Materials, Components, Accessories and Details.—Accles and Pollock, Ltd., steel tubing, stainless steel elbows; Aeroplane and Motor Aluminium Castings, Ltd., light-alloy and zirconium castings; Aipite Products, Ltd., joint washers; Alvis, Ltd., light-alloy castings; Andre Rubber Co., Ltd., washers; George Angus and Co., Ltd., seals; Anti-Attrition Metal Co., Ltd., bronze housings; B.R.D. Co., Ltd., blades (finished); B.S.A., Ltd., precision castings; Belling and Lee, Ltd., terminal blocks; Bell's Asbestos and Engineering, Ltd., dumbell-section tape; Birmetals, Ltd., Duralumin bar; Birmingham Aluminium Casting (1903) Co., Ltd., light-alloy castings and magnesium-zirconium castings; Thomas Bolton and Sons, Ltd., aluminium-bronze housings; James Booth and Co., Ltd., Duralumin bar; British Insulated Callenders Cables, Ltd., cables; British Thomson-Houston Co., Ltd., booster coils; David Brown Foundries Co., stainless-steel castings; Brown Bayley Steels, Ltd., steel forgings, stainless steel bar; Brown Brothers (Aircraft), Ltd., nuts; Bruntons, Ltd., alloy steel bar; C.W.C. Equipment, Ltd., Reglo switches.

C. G. Carlisle and Co., Ltd., stainless bar; Charles Churchill and Co., Ltd., screws; Clyde Alloy Steel Co., Ltd., steel bar (alloy); Coopers Mechanical Joints, Ltd., washers, shims; Cornercroft, Ltd., blank units; de Havilland Propellers, Ltd., propeller controller units, actuators, locator assembly; Diamond Screw and Cotter Co., Ltd., taper pins; Daniel Doncaster, Ltd., steel stampings and blade forgings; Dowty Equipment, Ltd., seals, hydraulic damper and Dowmic switch; English Steel Corporation, Ltd., steel stampings, alloy steel bar; Evered and Co., Ltd., plugs; Ferodo, Ltd., brake lining.

Firth-Derihon Stampings, Ltd., steel drop forgings, turbine blade forgings; Thomas Firth and John Brown, Ltd., alloy steel bar and forgings; Firth Vickers Stainless Steels, Ltd., stainless-steel bar and castings; Samuel Fox and Co., Ltd., alloy steel bar; Garringtons, Ltd., blade forgings; Govan Shafting and Engineering Co., steel bar; Hadfields, Ltd., precision castings; Hall and Pickles, Ltd., alloy steel bar; John Harper and Co., Ltd., Meehanite castings; Hellermann, Ltd., Helsyn sleeves; Henley's Telegraph Works Co., Ltd., cables; High Duty Alloys, Ltd., light-alloy stampings, blade forgings and Dural bar; High Pressure Components, Ltd., collet nuts; Hoyt Metal Co., of Great Britain, Ltd., whitemetal; Hughes-Johnson Stampings, Ltd., steel stampings.

Imperial Chemical Industries, Ltd., light-alloy and brass bar; Isospeedic Co., Ltd., centrifugal switches; William Jessop and Sons, Ltd., special alloy forgings; K.L.G. Sparking Plugs, Ltd., two-pin fireproof plugs; Kayser, Ellison and Co., Ltd., alloy steel bar; King Aircraft Corporation, clamps; Richard Kinger, Ltd., washers; J. H. Lavender and Co., Ltd., light-alloy castings; Light Metal Forgings, Ltd., light-alloy stampings and blade forgings; Lodge Plugs, Ltd., gland nuts, etc., ferrules, elbows, igniter plugs; London Electric Wire Co. and Smiths, Ltd., cables; Joseph Lucas (Gas Turbine Equipment), Ltd., bleed-valve assembly, burner assembly, fuel pump, fuel control unit, combined control unit.

M.A.M. Rubber Manufacturing Co., Ltd., cable sleeves; Manganese Bronze and Brass Co., Ltd., bronze bushes; McKechnie Bros., Ltd., brass bar; Measuring Instruments (Pullin), Ltd., switch; Metalastik, Ltd., rubber bushes; Metal Gravure Co., Ltd., nameplate; William Mills, Ltd., sand and aluminium-die castings; Negretti and Zambra, Ltd., pressure switches; Northern Aluminium Co., Ltd., Duralumin bar; Perry Barr Metal Co., Ltd., light-alloy castings; Plessey Co., Ltd., manufactured booster pumps, non-return valves, actuators, plugs and sockets, etc.; Precision Rubbers, Ltd., seals; Premier Spring Co., Ltd., spring.

Ransome and Marles Bearing Co., Ltd., bearings; Reynolds Tube Co., Ltd., steel tubings; William Robertson, Ltd., non-alloy steel bar; J. Rodgers and Sons, Ltd., blade stampings; Rotax, Ltd., linear actuator electric starter, terminal covers; Rotol, Ltd., tachometer, alternator, gearbox drive shaft; Rubery Owen and Co., Ltd., screws; George Salter and Co., Ltd., circlip, spring washers.

Sangamo Weston, Ltd., thermo-bulbs, leads, tachometer generators; Sheepbridge Steel Castings, Ltd., stainless-steel castings; Siegrist Orel, Ltd., cable markers and insulating sleeves; Small and Parkes, Ltd., cable straps; Smiths Aircraft Instruments, Ltd., transmitter, igniter plug, generators; Smith-Clayton Forge, Ltd., steel stampings; South Wales Forgemasters, Ltd., steel forgings; George Spencer Moulton and Co., Ltd., joint rings, rubber sleeving, extruded rubber section, synthetic rubber sleeves; Stainless Steel Wire Co., Ltd., stainless wire; Stampings Alliance, Ltd., steel stampings; Standard Telephones and Cables, Ltd., thermister pellets, suppressors and chokes; Sterling Metals, Ltd., magnesium/zirconium castings and aluminium castings; J. Stone and Co., Ltd., magnesium/zirconium castings and aluminium castings.

T. I. Aluminium, Ltd., light-alloy bar; Teddington Aircraft Controls, Ltd., flamestats, ductstats; Herbert Terry and Sons, Ltd., hose clips; Thermal Control Co., Ltd., thermocouples; Tubes, Ltd., steel tubing and shaft forging; G. Turton Platts, steel stampings; Ultra Electric, Ltd., throttle motor; Vokes, Ltd., oil filter assembly; James Walker and Sons, Ltd., packing rings; Wellworthy, Ltd., retaining rings and gas rings; Henry Wiggin and Co., Ltd., Nimonic steel bar; W. J. Wild, Ltd., tab-washers; Yorkshire Engineering Supplies, Ltd., bronze bushes, housings, etc.

AN ADDITIONAL LIST

APART from the many firms named above, in lists supplied by the manufacturers of the aircraft, we understand that the following have also supplied production materials, components, etc., or have provided equipment specified by B.O.A.C. for their Britannia operations:—

Abbey Panel and Sheet Metal Co., Ltd., prototype main engine cowling, production rear cowlings, and door assemblies, etc.; Aviation Developments, Ltd., special rivets, quick-release pins, etc.; Baynes Aircraft Interiors, Ltd., design of cabin furnishings and associated structures; British Oxygen Aro Equipment, Ltd., oxygen demand regulators specified by B.O.A.C.; Chelton Electrostatics, Ltd., aerial equipment; British Vapour Blast, Ltd., "Hydrabrasion" de-scaling process for titanium tailpipe shrouds; Delaney-Gallay, Ltd., wing de-icing heat-exchangers; Equator Wheels and Sections, Ltd., titanium and nimonic stiffening bands for Proteus 755; H.M.L. (Engineering), Ltd., hydrostatic test rig and mobile test rig; Helliwells, Ltd., ducting, sleeping-berth frames, luggage racks, etc.; Integral, Ltd., hydraulic motor-pump for feel simulator; Intermetric Processes, Ltd., processing of first titanium shrouds for Proteus; N.S.F., Ltd., switches in propeller control units; D. Napier and Son, Ltd., Spraymat anti-icing equipment; The Palmer Tyre, Ltd., oxygen reducing valve installation; R. B. Pullin and Co., Ltd., turn-and-slip indicator to B.O.A.C. specification (see also list above); Pyrene Co., Ltd., Bonderite "S.S.," used in cold forming of flame-tubes (see also list above); Scott Bader and Co., Ltd., "Crystic" and "Marco" polyesters; Spa Guilds, Ltd., manufacture of engine components; Western Manufacturing (Reading), Ltd., control-column stall-warning device; Williams and James (Engineers), Ltd., ground air compressor supplied to B.O.A.C. for ground servicing Britannia hydraulic accumulators.

BRITANNIA FLIGHT DECK

A Modern Airliner Cockpit Described in Detail

THE author of this article is Mr. G. Wansborough-White, A.R.Ae.S., F.S.F., of Bristol Aircraft, Ltd. His description of the Britannia flight deck, written from close personal acquaintance with it, provides a useful background to several of the articles on earlier pages of this issue.

THE equipment of the Britannia is necessarily complex—complex in that the aircraft achieves size, performance, load capacity and standard of comfort which, considered together, are now unmatched by any other civil aircraft. One would expect this complexity to be reflected in the flight deck; but the first, and surprising, impression is one of almost indecent simplicity.

To an airline pilot new to the Britannia there would be little to explain in the layout itself; this is practically self-explanatory, and careful design has reduced what could have been difficult to what is reasonable. This is in part due to the comparative simplicity of the gas turbine as compared with the piston engine, but also because instrumentation and layout have been subject to extensive development in close co-operation with B.O.A.C.—as, indeed, has the whole of the Britannia. This has continued during the entire project, from mock-up to prototypes, and has continued with production aircraft up to delivery. The B.O.A.C. Britannia flight deck is truly "custom-built," with the customer an active partner in development.

Operators other than B.O.A.C. will, of course, have their individual requirements, but the "unit" construction of instrument panels and the pedestal make new requirements reasonably feasible. Changes will mostly be those of alternative equipment, and not of basic re-design—a great advantage which stems from good design.

Crew Requirements.—Provision is made for an operating crew of five, comprising captain, first officer, navigator, radio operator and a supernumerary engineer carried at the discretion of the airline. This last officer has a jump seat (adjustable to two heights) between and behind the pilots' stations. Engine controls on the pedestal, and the roof panel controls (engine starting, fire, anti-icing and pilot's radio) are within easy reach, thus dispensing with a separate engineer's panel and controls. The supernumerary seat also serves as a convenient location for instruction, and can be used, if so required, by the navigator or radio operator.

The Britannia is licensed by the Air Registration Board for a minimum crew of three, and for test purposes has frequently been flown with two. This is possible because all controls—including normal emergency—are within reach of the pilots (or pilot and engineer) strapped in the pilot seats, while most of the radio is remotely controlled at the pilots' roof panel. With the exception of the navigator's Loran, the crew of two would have the navigator and radio stations at their effective control, with only the subsidiary electrical panels (E.2, E.7 and E.9 on the bulkhead) out of reach.

This simple and centralized location of control is a feature which, by doing away with the separate engineer's panel, reverses a past tendency for the cockpit to outgrow the pilot. It is of significance not only in itself but because it reflects an approach to the problem which has enabled so large and advanced an aircraft to have such a comparatively simple flight deck. The cockpit has been sometimes criticized as being too small, but this is difficult to understand; it has been known to accommodate eleven people! It is adequate and comfortable. As becomes the modern "office," it caters for business efficiency, and with minor criticisms, has the full approval of the "staff."

Panel and Control Layout.—This short survey cannot hope to cover all items in detail, but these may be studied by reference to the accompanying illustrations.

It was stated earlier that the flight deck is almost self-explanatory—a statement which in itself may now need some explanation. Fig. 1 shows a formalized layout of control panels, alphabetically labelled to S.B.A.C. standard. The list suggests the fact and the explanation—that instruments are grouped as functional entities, by system and by sense, and that the layout was as much designed by the pilot as by the draughtsman. With a few exceptions, each panel serves only one system. Such an exception would be the main and secondary electrical power failure warning lights located on Panels A.1 and A.3, but these must come to the pilots' immediate attention, and are clearly separated from the main flying instruments, which are contained within a white line. This feature is also evident on Panel A.2, where engine instruments are similarly segregated.

The white line as an aid to mental "focus" is not new—it has been used on military and civil aircraft since the end of the last war—but this basic idea has been carried further in what might be termed a system of "line indication." An example is the fuel panel, which displays the system in outline form, with its operation clearly portrayed. The electrical panels are similarly laid out as a working diagram, and such mental aids are invaluable for immediate perception of the state of the system, and thus in reducing crew fatigue.

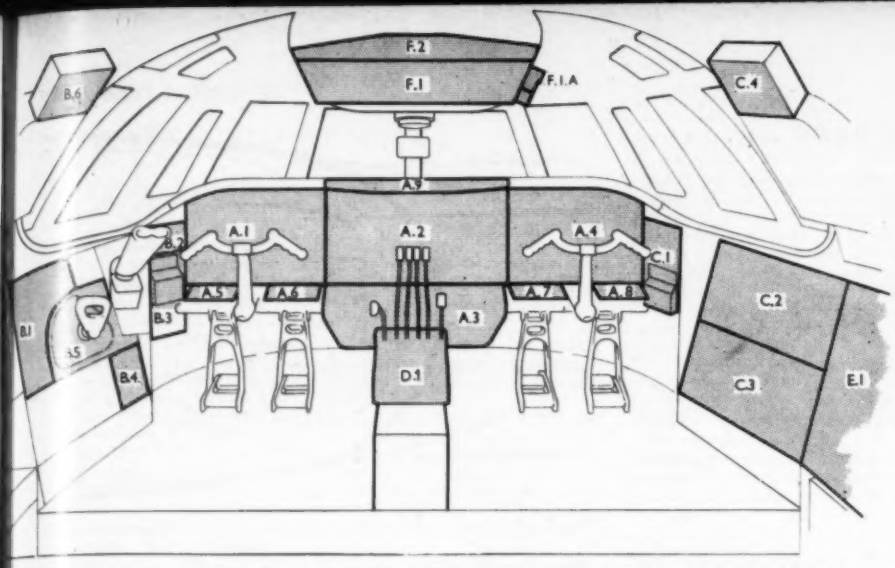
From the maintenance aspect, all panels are hinged to give access to the rear.

Flying Controls.—Space-saving has been achieved by, in addition to the measures already described, the design of the push-pull control wheel, with conventional movement for aileron and elevator. The rudder pedals incorporate mainwheel brake controls, and are adjustable for length; the parking brake levers will be seen forward of the pedestal.

Elevator trim is by duplicated hand-wheel on the pedestal, and transmitted through torque tubes and gearboxes to a servo-tab on each elevator; this may seem to encroach on a description of the flying controls, but it is included to explain the contrasting rudder and aileron trim, which is "mechanical" rather than directly aerodynamic, although the end result is the same. Aileron and rudder trim switches, on the pedestal, control electric motors

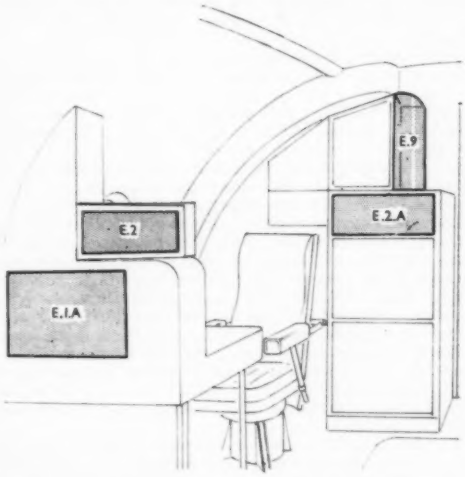
The cockpit of the Britannia 102—a "Flight" photograph taken in G-ANBE at London last week. The layout of the panels is illustrated on the facing page by diagrams.

"Flight" photograph



A.1 Captain's flying panel
A.2, A.3 Engines and propellers
A.4 First officer's flying panel
A.5-8 Dimmer switches
B.1 Hydraulics
B.2 Windscreen heating
B.3 Brake pressures
B.4 Windscreen switch
B.5 Nosewheel steering
B.6 Engine overspeed
C.1 Cabin pressure and temp.
C.2 Fuel
C.3 Air conditioning
C.4 Control-surface indication
D.1 Pedestal
E.1 Electrical generation
E.1A Electrical secondary supplies
E.2 Electrical subsidiary control
E.2A Electrical subsidiary control
E.9 Electrical isolation control
F.1 Starting, fire and icing
F.1A Leading-edge temp.
F.2 Pilots' radio

Fig. 1. Grouping of the Britannia 102 panels, looking forward and (below) aft. With a few exceptions, each panel serves its own system.



giving a bias to the centring springs, acting as the artificial feel of the two control circuits. (The elevator feel system is discussed later, being hydraulically operated.) A "feel" system is necessary because the main control surfaces are servo-tab operated, with small feed-back to the pilots' controls.

Owing to the free nature of the main flying-control surfaces, indication of their freedom of movement is necessary during pre-flight check, and is shown by Desynn type indicators, at Panel C.4, giving angle of movement. On the ground, slipstream effect on the tail is sufficient to actuate rudder and elevator, but forward speed is required to move the ailerons. (In practice the ailerons are checked by movement due to lock release, when a torsion spring gives a downward deflection.) Five warning lights centralized on Panel A.9 give indication of locked control surface hydraulic jacks. As an added safeguard against take-off with locked controls, only two throttles—one on each side—will open to full power with the control surfaces locked; together, all four throttles will not open beyond flight idling. The control locking lever itself is spring-loaded to the off-position (when the hydraulic locking jacks are isolated from the main hydraulic system) and also has a safety catch. All this is more than a safeguard—it is *impossible* to make a locked take-off.

To prevent wallowing and the "Dutch roll" effect associated with a large dihedral angle, the wings of the Britannia have been kept to the low angle of 3 deg, but effective dihedral angle in a turn is effected by one servo-tab in each aileron being connected to the rudder circuit. Minimum rates of turn can thus be made with rudder alone but, if prolonged, some back elevator-pressure would be needed to keep up the nose. This feature can be of value to make small course-corrections by rudder, as during final approach.

Although it has its own minor complications, the flying-control system has the great advantage of obviating the need for powered controls, which must be duplicated. With the exceptions described, the controls are conventional from the operational point of view, and are well liked by pilots, of whom over 100 have now trained on Britannias.

Flight Instruments.—Flying instrumentation within the white "focus" line consists of A.S.I. altimeter, artificial horizon (on which the first officer's instrument provides horizon reference for the Zero Reader), Zero Reader indicator, directional gyro (C.L.2 compass repeater) and the instrument landing indicator of the I.L.S. system. All gyro instruments are by Sperry, and are duplicated for the two pilots.

Outside the focus line are the Zero Reader course selector and control panel, turn-and-slip and rate-of-climb indicator. The Machmeter—which emphasizes that the Britannia is in the high-speed class, and is, incidentally, a useful navigational instrument—is on Panel A.3, above the distance-measuring indicator, which is properly part of the radio system. The magnetic compass is the P.12, centrally mounted on the windscreen, but this will be replaced in later variants by the stand-by E.2B compass, of smaller size.

Engine Instruments.—Engine controls are centrally mounted on the pedestal with access for both pilots, and, as with all the controls on the pedestal (with the exception of the elevator trim-wheels) are not duplicated. Panels A.2 and 3, directly above the pedestal, mostly serve engine instrumentation. Again, a white line serves as a mental focus, emphasizing engine torque, compressor r.p.m., propeller r.p.m. and, at the top, the four feathering buttons with incorporated engine fire warning lights. The lower Panel, A.3, highlights the propeller indicating lights and the jet-pipe temperature gauges, and alongside these lie the oil contents, oil temperature and oil pressure gauges. Thus the basic facts of engine running are simply and centrally displayed. It is well done, and demonstrates the relative simplicity of the gas turbine as compared with the piston engine.

The throttle control system, by Ultra, gives electrical actuation of engine throttle valves and takes care of that sensitive aspect of the gas turbine, a controlled rate of acceleration irrespective of snap throttle movement.

Compressor r.p.m. is sensitive to density (varying with height and ram effect, dependent on speed) and in the Britannia this is automatically governed by the throttle system, a point appreciated by the pilot who would otherwise have (or, maybe, has had) to chase cruising c.r.p.m. with the throttle.

A "remote" or free throttle was, as with the flying controls, viewed at first with some pilot-apprehension; but it is now liked, as it works accurately and well.

Roof Panel.—This is in two separate parts, the pilots' radio panel (F.2) and the engine starting, icing and fire panel (F.1).

The radio panel gives independent control of V.H.F., A.D.F., H.F., voice range filters, I.L.S. and D.M.E., and all but the last two are duplicated controllers. Pilots have complained that these radio controls are awkward to reach; but if this is a criticism, then it is probably true of all roof radio installations. An advantage of the arrangement is that much airline navigation is by radio, and the panel is convenient to the supernumerary crew seat, which can thus be used for navigation; so it neatly suits the purpose of the three forward seats. If a flight engineer is carried, then F.1 is equally convenient, so that the crew pattern remains flexible. Before passing the F.1, the dividing line is a radio-frequency chart which pulls down as a "blind" between the two panels.

F.1 is split into defined functional sections, as shown in the key diagram. A salient feature of design is that in the case of switches and warning lamps for powerplant fire control the idea of visual focus is extended to one of "guide" focus, so that the

BRITANNIA FLIGHT DECK . . .

units relevant to each engine are separated by a plastic rail, which also acts as a switch guard. The sequence of drill operations is followed by making the hand movement rearward from the front of the panel and all switches will be facing downward/forward when the drill is completed. It is in emergencies that mistakes are more likely to occur, and with a duplicated fire warning light in the appropriate channel the "guide" makes the drill almost foolproof. Fire warning is by bell, and by warning lights that are part of the feathering buttons on A.2. Cargo-hold fire control is on an adjacent panel; and whilst discussing the roof it is perhaps pertinent to note that the hold smoke-sampling lantern is at the navigator's station, visible to the whole flight deck, and that the access hatch to the front hold is in the floor. With portable fire-extinguishers for the flight deck and passenger cabins, fire control is comprehensive.

F.I.A., for leading-edge temperature gauges, is an additional panel which tends to spoil the composite design of the original. This, however, will be redesigned into a fuller panel in later Britannias.

Pedestal.—The propeller console is by de Havilland, as part of the composite system of propellers and associated electrically actuated, hydraulically operated propeller controls. By means of centre-off switches, adjustment is made to individual and combined propeller speeds, and selection for master propeller synchronization and superfine pitch (on/off). Emergency control is similarly actuated, switches being housed beneath a hinged safety-cover.

Superfine pitch (2 deg with minimum thrust and maximum drag) is used for normal aerodynamic braking on the landing run and is also necessary on the ground to enable the propellers to run fast enough (500 r.p.m.) to keep the generator charging while throttled back to idling, when there is just enough forward thrust for taxying.

Propeller reversing is an additional and very powerful means of braking which adds to operational flexibility. This is particularly true of landings on icy runways and in the accelerate-stop case; although reversing as a ground manœuvre is not encouraged as a routine, it has often proved its worth, as when a tractor has not been available. Reverse is initiated by the master selector (on the pedestal alongside the throttles), which also lifts a guard flap in the reverse-power range of the throttles. Upward and rearward movement of the throttles from the idling position then reverses propeller pitch and applies the required power. There being two separate actions to obtain propeller reverse no further safeguard is required, but superfine is protected from inadvertent operation by a weight switch on the nosewheel; and drill requires that superfine is selected only when the aircraft has touched down.

Smith's Aircraft Instruments are responsible for the S.E.P.2 autopilot, controls for which are mounted on the pedestal ahead of the propeller console; the emergency release switch, however, is on the horn grip of the flying-control wheel (its counterpart being the two-way intercom-R/T. switch), and the autopilot heading selector is on A.3. Development is proceeding on an approach coupling (I.L.S./autopilot) and, as selective alternatives, a speed-lock (pitot/static system/autopilot) and height lock (static system/autopilot). Whilst not part of the autopilot, an associated development of interest is an "automatic throttle" which aims, by adjustment of engine power, to give constant speed on the approach irrespective of attitude—by which time any crew's rest-compartment will possibly be redundant.

The pedestal also carries stand-by throttles (in the form of "inching" switches), control locking lever, elevator trim wheels, aileron and rudder trim switches, compressor governing r.p.m. adjustment, undercarriage and flap selectors and the hydraulic off-load of the Hobson artificial-feel system for the elevator circuit. On the side may be seen the throttle friction nut, and the undercarriage warning horn cut-out switch which is used during training and in the descent case when throttled back; opening of the throttles then re-sets the circuit.

Making a distinction between "flying" and "control" as between continuous flying and occasional adjustment of the aircraft, the pedestal is wholly "control," and in this respect could not be bettered; the only intruders into this group are the two A.D.F. volume-control switches.

Warning Lights.—The warning system is very complete, and comprises no fewer than some 45 lights, amber, red and white. As an essential part of the line-indication method of presentation, there are 109 magnetic indicators in the fuel, anti-icing, air-conditioning, hydraulic and electrical systems. A total of 154 "signals" seems far from simple; but if the systems are complex they are thus self-evident, and in this respect they make pilotage easier.

Hydraulics.—The main hydraulic system of the Britannia serves undercarriage operation, wheel braking (Dunlop, with the Maxaret anti-skid device) control-surface locking and nosewheel steering. The undercarriage selector is seen on the pedestal, and is clearly distinguished from the four-position flap lever. (Flaps, incidentally, are electrically operated, and the emergency "inching" switches are at the bottom right corner of A.3). Emergency selection of the undercarriage is at the hydraulics panel (B.1), and a hand-pump behind the captain's seat and below floor level serves for ground operation and for stand-by emergency in flight. Brake pressure gauges are on B.3, and the system allows for some 20 brake operations from a full accumulator without further charging. Windscreen wipers are Dunlop Maxivue, with an independent hydraulic system electrically driven.

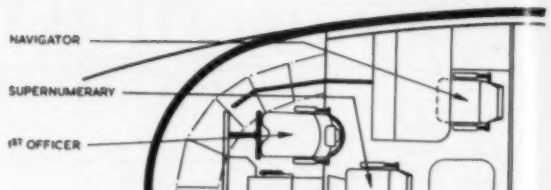


Fig. 2. Britannia flight-deck accommodation shown diagrammatically.

Artificial feel, deemed necessary with the free flying-controls of the Britannia, is achieved in the elevator circuit with the Hobson system, acting on displacement from neutral and with a feed-in varying with airspeed; also peculiar to the elevator is a hydraulic damper. The offload for the Hobson system is at the rear of the pedestal, with warning lights for high- and low-pressure accumulators on the shroud panel (A.9.2).

Alongside the main hydraulic panel (B.1) are the search-radar controls and display (B.5), the windscreen heating control panel (B.2) and, below this, the captain's intercom station box.

Above B.1 and over the port oxygen regulator is B.6, the engine overspeed control panel, with a spring-loaded cover to prevent inadvertent operation of test switches.

Fuel. Panel C.2 makes use of the visual-diagram indication system, painted lines—representing the fuel lines—linking the contents and flow gauges, pump switches and cocks in correct operational relation to one another. Operation of the system is clearly shown and, together with the magnetic indicators, the arrangement makes for one of the neatest fuel panels in recent aircraft.

Air Conditioning and Pressurization. Control of air conditioning is from Panel C.3 (below the fuel panel), but the cabin height, pressure and rate of climb are instrumented at C.1, being conventional flying instruments open to cabin atmosphere and not connected to the pitot-static system. An account of pressurization and air conditioning is no part of this survey, but suffice it to say that a complex system is simply operated from the cockpit, with all controls within easy reach.

Automatic temperature control is divorced from C.3, and selection of temperature is made from the steward's panel in the bar unit.

Pressurization is selected with the Normalair Type D controller, and alongside the panel is the cabin-pressure relief-valve control wheel. As part of the panel, but not part of air-conditioning, are ground test instrumentation and various switches which are not dignified with a panel number of their own; but the distinction is quite clear, and the rule of "grouping" by function is not contravened.

It might be added that air is tapped from the engine compressor and not from a separate blower, which is one of the reasons contributing to the popular name of "Whispering Giant." In this, the Proteus has an unusual advantage.

Electrics. The Britannia 100 generates some 130 kVA, the equivalent of the normal requirement of a village of one thousand inhabitants, so that the control of this power within the confines of the cockpit electrical panels calls for careful design where space is at a premium. Bristol may fairly claim to have achieved a comprehensive, yet simple, design in Panel E.1, the main electrical panel; and here, again, full use is made of line indication with magnetic indicators. Subsidiary electrical panels are on the front of the navigator's station, at E.1A and E.3, both of which may, albeit with an awkward turn around, be reached from

BRITANNIA FLIGHT DECK . . .

the first officer's seat. Fuse and isolation panels are on the rear bulkhead—E.2A, E.7 and E.9.

The electrical generation equipment of Britannia has been evolved in collaboration with Rotax, Ltd. Electrically operated services include propeller and tail de-icing, throttle control, instrumentation, lighting, hydraulic selection, engine starting, flaps, and radio and radar. Electricity is used for everything, in fact, not served by hydraulics.

Lighting. General lighting of the flight deck is by shaded, recessed, 28v D.C. tungsten lighting, whilst flight instruments are illuminated by red and white lighting, the dimming switches being at the small lower panels, A.5-8.

Roof panels have white tungsten lighting, but on the 300 and later variants F.1 will be redesigned to have the Thorne "Translite," a system of internal filaments. White lighting is used for the pedestal, floodlit from above, and also for the navigator and radio stations. To prevent windscreen reflections at night from these stations, night curtains can isolate the pilots and, if necessary, the supernumerary crew-member. Fluorescent instrument lighting is not used in Britannia.

Windscreen. Ten separate panels form the windows of the flight deck, of which six are the windscreen proper, being an integral part of the front pressure bulkhead. The six central panels are of Nesa (Pittsburg Plate Glass) type flat laminated glass with thermal heating elements (controlled from B.2) and the two side panels are of curved Perspex, as are the two roof panels on each side. These last allow a good view in banked turns, a necessary feature with increasing traffic at airports. The variable-speed windscreen wipers, as noted, are hydraulic, with individual controls at B.4 and C.3.

The two outer Nesa panels, for draught-free direct vision, are mounted on a toggle-action carriage ensuring a sound pressure-seal when closed, and enabling them to be slid aft for opening, in which position they are retained by spring catches.

Some trouble was experienced with misting of the plastic side-windows; the problem has been overcome with a further glazing and an electrically heated inter-space with thermostatic control.

Navigating Station. The navigator commands full facilities with Loran and a Kelvin and Hughes periscope sextant and periscopic drift-sight; instruments are A.S.I., altimeter, clock, outside air temperature, A.D.F. master receiver and bearing indicator, and the Sperry CL.2 master compass. In the gangway is an adjustable platform for use with the periscopic sextant, and recessed as part of the floor structure. As a general sighting point, but not as an astro-dome proper, the emergency escape hatch in the roof is to be modified to form a window.

To those who recall wartime navigation, the chart table will appear of luxurious proportions, and such is the state of the art that the navigator has his own private book-case. This is alongside the Loran APN9 viewer, as distinct from the "public" crew book-case behind the radio seat, which is for flight and maintenance manuals and for ship's papers.

Where navigation is mostly by radio, then the navigator can conveniently do his work from the supernumerary seat. As has already been stressed, Britannia crew requirements are flexible, and there is the space and the facilities for them to be so.

Radio and Radar. Signals facilities are comprehensive. For B.O.A.C. they include duplicated high-power H.F. transmitters and receivers with direct and pilots' remote control; twin multi-channel V.H.F. transmitter/receiver (pilots' control only); twin manual A.D.F. receivers; DME, 200 m/cs; Loran AN/APN9 (at the navigator station); cloud/collision warning radar E.120 (captain, and second indicator for navigator); fully tunable H.F./M.F. receiver (direct control at radio station); intercom, with service selection; and passenger announcement.

Items at the radio station are mounted in specially designed racking, enabling units to be readily removed or serviced. Radio in the pilots' roof panel has already been described.

Each of the four permanent crew-stations has intercommunication with separate jack-boxes, and additional boxes are available for the supernumerary crew-member.

A point worth recording is that on the recent Atlantic flight of G-ANBJ the radio gave an excellent account of itself, and H.F./R.T. contact with base was maintained throughout the crossing right into New York—a fact which was not un-noticed by radio operators in other aircraft.

Radar is now the hall-mark of the modern intercontinental air-liner. This fifth sense, a storm-warner and navigational aid, was of great help during the icing trials of Britannia—not for avoiding trouble, but in finding it!

Furnishing and Ventilation. All instrument panels for B.O.A.C. are of matt black finish, while C.P.A. will have matt grey for their Britannia 314. Seats, fully adjustable for the pilots, are covered with green leather and green linen loose covers (maroon for C.P.A.) whilst wall-trim and head linings are in grey/green; all are fully fireproofed. Floor covering is also in green, these colours being B.O.A.C. standard for all their fleets.

Navigator and radio operator may eat in luxury, and the pilots are at last given a cup-holder (sunk above the forward instrument panels) and all stations have an ashtray—smoking being permitted at all times except during landing and take-off. The crew-door incorporates a meal hatch and a circular window, but British operators do not yet specify a requirement made by some airlines: that the crew door shall be lockable—from inside!

Side and upper windows have roller blinds, whilst sun protection from forward is by sun visors for the pilots.

Fresh conditioned air to the flight deck is by a duct forward, and the four permanent stations each have a cold air supply with an adjustable air louvre, two extra louvres being available. Heating may be controlled independently of the main passenger cabin.

Emergency Facilities. As distinct from aircraft operating emergency systems, the following equipment is located in the cockpit: Fireman's axe; CO_2 hand extinguisher; ditching hatch in the roof; smoke mask; crew life belts; oxygen equipment. The permanent crew-stations have demand-type oxygen masks; and, as is general practice, it is a requirement that whilst the aircraft is pressurized, one pilot be strapped in and have his oxygen mask immediately available.

Later Variants. The flight deck of the Series 310 Britannia (Variant 312 for B.O.A.C.) is similar to the Series 100 described. Significant changes in detail are the enlarged fuel panel, radio and the Smiths Flight System (described in *Flight* for August 19, 1955). The 305 (Northeast), 313 (El Al), 314 (Canadian Pacific), 252 (Ministry of Supply) and 253 (Royal Air Force) have similar changes, together with detail modifications for their own particular needs.

Northeast are alone in having to comply with C.A.A. regulations, and in addition, have specifications to meet their own operating requirements. This calls for various changes, the major being the deletion of the navigating station, the space now becoming a crew baggage-compartment, and forward of this will be an engineer station, incorporating electrical, fuel and air conditioning panels. The supernumerary seat here becomes even more versatile and, as the new engineer-seat, gives access to engine controls and to the new station. An important point is that the first officer can also reach the engineer panels, so that the original conception of a two-man crew could again be possible. Radio will be fully controlled from roof panel F.2, with the radio racking amended accordingly, and no radio operator will be carried. The introduction of an engineer panel appears to challenge the earlier statement that Britannia layout was simple because it didn't need one. But the case is strengthened—now there is no radio operator and no navigator! And the "engineer" panel is not new; it is just the existing panels re-located. This useful exercise grooms the cockpit for the American market, and with B.O.A.C.'s inter-continental layout, the Britannia is set for world-wide operation.

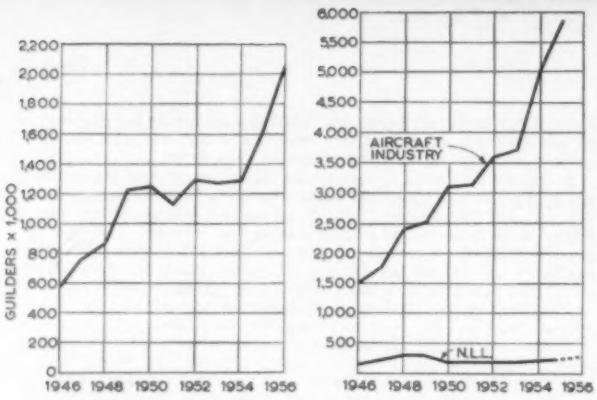
With some 8,000 flying hours, the Britannia has a reputation as an efficient, responsive and economic aircraft. The whole must contribute to this reputation; but if the heart of an aircraft is in the engine, then the brain is in the flight deck. Britannia is not only beautiful, but intelligent.

R.Ae.S. LECTURE CONTEST

TWO young finalists in the N. E. Rowe Medals Competition of the Royal Aeronautical Society gave lectures before the Graduates' and Students' Section of the Society in London on Tuesday, January 15. Both lectures had been presented previously at Branch meetings (at Bristol and Southampton respectively); after the London meeting, the author of the Bristol paper, Mr. P. F. Sutherby, was adjudged winner in his class of the contest.

The competition, inaugurated this year, is for the best paper on a technical topic by a young member of one of the branches of the Society. One medal is awarded for members under 21, and one for those between 21 and 26. Normally, judging is by the Branches Committee of the Society; in the case of a tie in either class final selection is made following presentation of the papers at a meeting of the Graduates' and Students' Section in London.

The two papers presented on January 15 were in the over-21 class, and comprised *Possible Flight Paths for Helicopters*, by Mr. P. F. Sutherby—previously a member of the Bristol branch and now with Elliott Brothers (London), Ltd.—and *Fins*, by Mr. J. Wolkovitch, B.Sc.(Eng.) (previously of the Southampton branch and now a Research Fellow at the College of Aeronautics). After the two speakers had presented their lectures and answered questions from the audience, the winner was selected by the five members of the R.Ae.S. Council who were present. In the under-21 class, it was announced that Mr. R. D. Trender (Halton branch) was the winner with his paper *The Development of Parachutes and Ejector Seats*.



An indication of the scale of Dutch aeronautical effort is provided by these curves taken from Prof. van der Maas' paper. On the left, aeronautical-research expenditure; right, personnel available to the Dutch aircraft industry and the N.L.L.

Development in the Netherlands

Points from an R.Ae.S. Lecture

AS briefly recorded last week, on January 24 Professor Dr.Ir. H. J. van der Maas, F.R.Ae.S., of the department of aeronautical engineering at the Technological University of Delft, was due to read a paper on *Aeronautical Research in the Netherlands* before the Royal Aeronautical Society. The author prefaced his account with the reminder that, after World War 2, his country had virtually to rebuild an aviation industry from scratch, and also had a considerable amount of research leeway to catch up. After ten years the rebuilding stage was more or less complete.

Curves of annual governmental expenditure on aeronautical research and man-power in the Dutch aircraft industry [published here] gave an idea of the overall magnitude of activity, and on the latter graph was plotted the personnel strength of the National Luchtvaart Laboratorium, i.e., national aeronautical research institute. The total vote for current expansion of N.L.L. facilities was approximately £2.1m. At present the N.L.L. employed 65 graduates, 105 other technical staff, 65 workshop personnel and 65 administrative and internal-service workers.

For the past 15 years the backbone of N.L.L. aerodynamics had been a pair of low-speed tunnels, one with a 5ft-square working section running at up to 130ft/sec and the other 7ft by 10ft with a maximum speed of 260ft/sec. The bulk of the latter tunnel's time in recent years had been devoted to research for the Fokker F.27 Friendship. These facilities were now being supplemented by high-speed tunnels.

Of the new tunnels the major installation was a transonic (originally designed as subsonic) variable-pressure tunnel with a Mach range up to 1.3, a working section 5ft by 7ft and a 20,000 h.p. drive. It was hoped to start calibration runs on this tunnel in the spring of this year. A smaller (1,200 h.p.) tunnel, originally planned as a pilot design for the 5ft by 7ft unit and with a test section 1.4ft by 1.8ft, was completed as a subsonic facility in 1955. Earlier, in 1947, a small 1½in-square supersonic tunnel was commissioned; it had reached Mach numbers up to 6 and had been instrumental in the development of the Erdmann interferometer.

A new project, said Prof. van de Maas, provided for the construction of a pair of supersonic tunnels. One would have a test section 5ft wide and a height changing from 4ft at Mach 1.4 to 3ft at Mach 4. The second would be a much smaller unit, capable of reaching Mach 6 with a 12in by 7in section, and fed from the main tunnel's 20,000 cu ft storage for runs of several minutes. The N.N.L.'s tunnel equipment is summarized in the table.

The lecturer went on to discuss problems of flutter, and noted in particular the investigations completed on the rotor of the Kolibrie ramjet tip-drive helicopter. These led to the development of a theory considering flow about a cylinder co-axial with the rotor. Unrolling the cylinder generated a train of aerofoils and the corresponding two-dimensional flow was evaluated. The programme had established reduced rotor-blade damping which might be an important factor in considering blade vibration caused by the varying downwash along the disc circumference. Other investigations for the Kolibrie had led to the self-adjusting blade system now employed, with greatly enhanced stability characteristics, and had also determined the behaviour of the tip-mounted ramjets.

Succeeding sections of Prof. van der Maas' paper dealt with the extensive Dutch investigation into three-dimensional laminar boundary layers, gust loads and stability derivatives. The author then turned to actual flight testing and pointed out that, largely as a result of the work done by the *Centre d'Essais en Vol* at Bretigny, it was now practicable to measure performance in non-steady flight. The N.L.L. had evolved special instrumentation — a photo-recording pendulum inclinometer and a normal accelerometer, a vane-type angle-of-attack indicator and a longitudinal accelerometer, the latter pair both with electric servo or synchro indication—and had conducted non-steady tests with an Si204.

Prototype testing had required further development of specialized instruments and techniques. Investigation of the forces and moments on the wing of the Fokker S.14 at transonic speeds was undertaken with 49 equally spaced orifices around a representative wing section coupled to potentiometer-type transducers.

Very extensive research had also been undertaken by the N.L.L. into structure and material testing. In particular a great deal had been done in increasing fundamental knowledge of fatigue in riveted and Redux-bonded structures, and in the investigation of cumulative damage and crack-propagation. Special programmes of testing concerned the static and fatigue properties of components made from glass-fibre-reinforced plastics, and ultrasonic testing (which might be applicable to bonded joints).

In conclusion, Prof. van der Maas outlined the work done by the Technical University at Delft. Extensive in-flight readings had been taken during basic boundary-layer research, during which a method had been evolved for estimating the transition point without disturbing the flow around the wing. The author described the method adopted in some detail.

The principal Delft wind tunnel was a 4ft by 6ft low-turbulence facility with a maximum speed of 400ft/sec. It had been used, *inter alia*, for an investigation into the problems of boundary-layer control by suction. To obtain experience in this field a simple two-dimensional model was built, which could be provided with slots at one per cent and 40 per cent chord, or a porous surface from 30 per cent chord to the trailing edge. It was in the course of investigations with this model that the method for predicting the boundary-layer transition region was determined.

Delft employed an Auster J.5B Autocar for general flight research, and the author produced the results from a series of measurements of stick-fixed, constant-power position of c.g. for neutral stability. Two methods were employed, derived from the moment curve and the slopes of the trim curves. Also available to the University was a structural-test laboratory, and a small blow-down supersonic tunnel was being completed. For general flight-dynamics research a modest analogue computor had been designed and built. One of its particular features was the low-drift of its amplifiers, permitting computations of relatively long duration on a true time-scale.

WIND TUNNELS OF THE N.L.L.

	In Operation				Building	In Design Stage	
	Low-speed	Small low-speed	Small Supersonic	Pilot tunnel	Transonic	Supersonic (1)	Supersonic (2)
Working section size	Closed 7ft x 10ft	Open 5ft x 5ft	Closed 1¼in x 1¼in	Closed 1.4ft x 1.8ft	Transonic 5ft x 7ft	Free jet 10-7in x 12in	Free jet 4-3ft x 5ft
,, length	13ft	7ft	1¾in	3ft	28ft	1ft	5ft
R (chord of A.R. = 5)	2.2 x 10^6	0.5 x 10^6		0.8 x 10^6			
Max. ft/sec or Mach number	260	130	M=0.5 to 6	Max.M=1.0 (empty working section)	Max. M=1.3	M=1.4 to 6	M=1.4 to 4
Turbulence level	3-4 per cent	4-5 per cent		Low (8 screens)	Low (25 screens)	Low (5 screens)	
Available h.p.	600	50	25	1200	20,000	6,200	6,200
Pressure (ata): settling chamber			1-170	1	Variable: 1/8-4	Max. 40	Max. 14
Speed control	Ward Leonard	Ward Leonard		Variable pitch and frequency	Variable pitch and frequency	Flexible nozzles	
Date	1940	1940	1948	1954	Expected to be ready for operation: 1957	Expected to be ready for operation: 1958	

V.T.O.L. Powerplants

Novel Suggestions from an American Engine Manufacturer

ON Wednesday last, at the Institute of the Aeronautical Sciences meeting in New York, Mr. P. G. Kappus of the General Electric Company's Flight Propulsion Laboratory Department, was due to give an outstanding summary of the powerplant layouts which can be considered for V.T.O.L. aircraft. A summary of his paper follows.

He began by saying that, in the military field, there was an urgent need for increased mobility and dispersal; and while the helicopter had proved of tremendous importance to the armed forces it had inherent speed limitations and made very high demands on skilled maintenance. From true V.T.O.L. systems a variety of support vehicles as well as combat types would emerge, combining high subsonic as well as supersonic speed capabilities, with no need for runways.

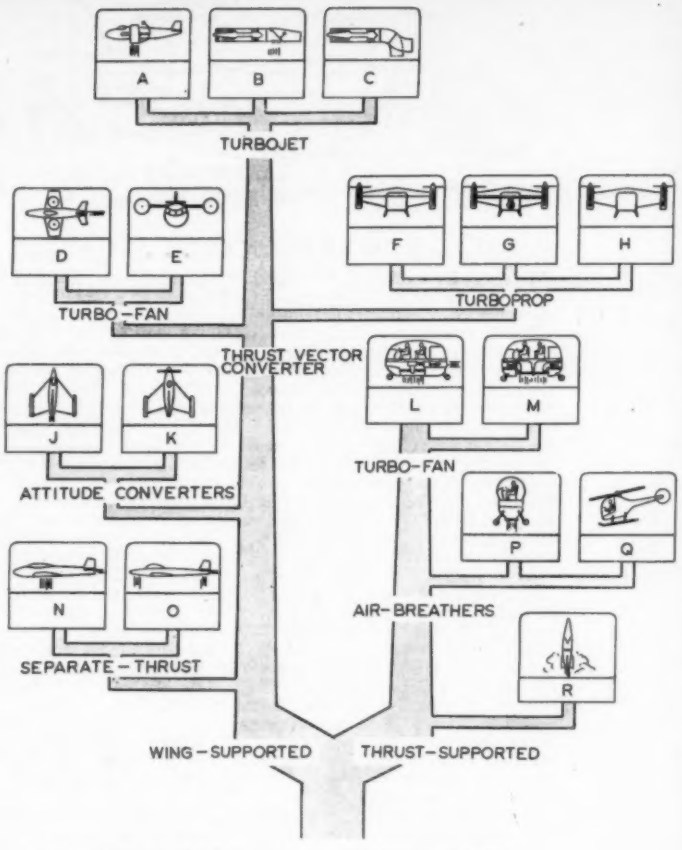
Possibly even greater was the importance of commercial and civil V.T.O.L. vehicles. High-speed V.T.O.L. feederliners promised to replace not only the airport-city coaches, but also the short-haul transports on to stage-lengths of up to several hundred miles. It might come to pass that fewer and larger airports would each serve several cities about 100 miles away. Big, supersonic airliners would operate medium and long-range services while V.T.O.L. feederliners would provide inter-city and city-airport transport

Mr. Kappus also suggested giving the family-car true V.T.O.L. capability: "Looking ahead twenty to thirty years, here's an opportunity for true progress that may well dwarf the tremendous evolution that started with Henry Ford's Model T."

The lecturer emphasized that "Practical V.T.O.L. capability will be reached only through powerplants of extremely low weight, combined with acceptable cruise fuel consumption. It would not be achieved through the use of present conventional engines."

Although money was being spent to develop radical V.T.O.L. airframe concepts, not enough was being done to find the propulsion system. Turning his attention to methods and arrangements, Mr. Kappus said, "Our latest engines build up much of their required high-speed thrust as a result of their own speed in a fascinating boot-strap operation. The thrust at high supersonic Mach numbers has little relationship to the take-off thrust, and we can visualize engines powerful enough to propel airplanes with Mach numbers as high as the structure can stand, and yet delivering a take-off thrust considerably below gross weight. Another point is that there are a great many important applications for V.T.O.L. where supersonic speed is not needed, and where cruise thrust requirements are quite modest. In this case, a propulsion system of extremely wide power range is required, combining very high take-off thrust with a cruise thrust, at good fuel economy, of less than 10 per cent of full power. Here, the required flight performance of the engine is far under the power level needed for V.T.O.L. V.T.O.L. will not just happen. We have to make a determined effort to create propulsion systems with novel and very specific characteristics, representing a new advance in power/weight ratio which combine efficiency at very low partial load with tremendous take-off power.

"One of the most important objectives in the near future should be a thorough investigation and evaluation of the most promising V.T.O.L. engine systems, properly matched with airframes that utilize their inherent capabilities to the fullest extent and result in the ideal engine/airframe combination for the various military and commercial requirements. Fig. 1 presents a 'family tree' of V.T.O.L. engines that shows quite some variety in the propulsion field. Our tree has two main branches, leading to engines for wing-supported systems on one side and for pure thrust-supported vehicles on the other."



A Rotating engine mount.
B Cascade deflector.
C Rotating tailpipe.
D Fan-lift, conversion jet.
E Fan for lift and cruise.
F Mechanical propeller interconnection.
G Pneumatic propeller interconnection.
H No propeller interconnection.
J Jet tail-sitter.
K Propeller tail-sitter.
L Mechanical fan drive.
M Pneumatic fan drive.
N Jet cruise, jet lift.
O Jet cruise, rocket lift.
P Turbojet.
Q Shaft turbine.
R Rocket.

Fig. 1. The V.T.O.L.-propulsion family.

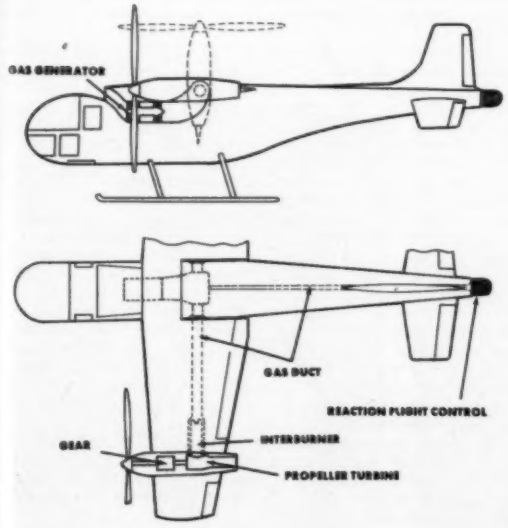
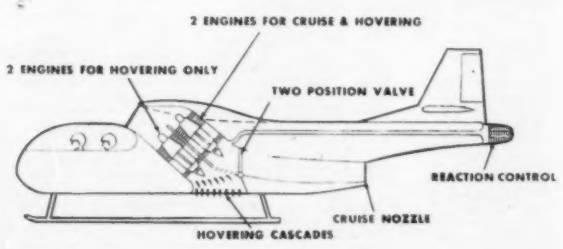


Fig. 2 (left). Turboprop for V.T.O.L. aircraft. Principle: Two or four pneumatically interconnected propeller turbines powered by a common gas generator. Application: Tilt-wing or deflected-slipstream aircraft.

Fig. 3 (below). Turbojet propulsion. Principle: Four lightweight turbojets for take-off and landing (two shut down, two produce thrust during cruise). Application: Fixed-wing high-speed, with short hovering time.



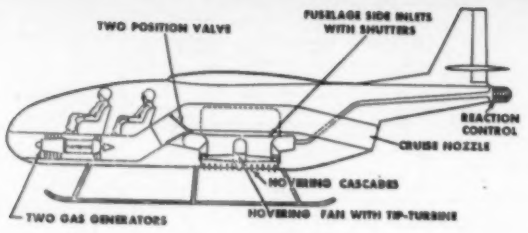


Fig. 4. Convertible turbo-fan. Principle: Two lightweight gas generators operating as turbojets for cruise (for take-off and landing they drive a fan through a tip turbine). Application: Fixed-wing high-speed V.T.O.L. aircraft with long hovering time.

V.T.O.L. POWERPLANTS . . .

The speaker continued, "I would like to point out four distinctly different powerplants that seem to offer special advantages for certain applications. First, for a tilt-wing utility and assault V.T.O.L. transport, of fairly conventional appearance, a turboprop arrangement, as shown in Fig. 2, seems to deserve attention. Instead of two separate, but mechanically interconnected, turboprop engines a central gas generator could be used. This unit is identical with a turbine compressor unit of a modern, light-weight free-wheeling turbo-shaft engine. The hot, pressurized gases produced by it are ducted through the tilted wing to free turbines, driving the two propellers through reduction gears. The power output could be increased for take-off through the use of interburners. . . . In comparison with the mechanically inter-connected separate turboprop solution, this arrangement offers numerous advantages in mechanical simplicity, weight, cruise economy and, possibly, reliability, and seems well worthy of closer evaluation.

"For high-speed applications with short hovering times, a simple cluster of four light-weight turbojets, installed as illustrated in Fig. 3, may have merits. . . . The jet is directed downward through cascades, which permit slight variations in thrust direction in order to build up speed. After the wings have produced adequate lift, two of the four engines are shut down and the mass flow from the remaining two is directed through a suitable flap-door valve to a tail-pipe, thus producing cruise thrust in the horizontal direction. This system promises early availability, using fairly conventional engines of very light weight at high subsonic speeds. It has a high fuel-flow during the hovering phases, but this may well be offset by the attractively low weight of the complete propulsion system.

A similar but more elaborate arrangement shown in Fig. 4, using two turbojet engines large enough to satisfy the cruise-speed requirements, but not powerful enough to produce sufficient direct lift. For take-off and hovering, the turbojet mass flow is utilized to operate a tip turbine mounted on the rim of a fan rotor that converts the small high-energy mass flow of the turbojet into the large, low-energy mass flow of a high-by-pass-ratio turbo-fan or ducted propeller. This conversion results in adequate lift and produces a hovering s.f.c. approximately half to one-third of that of a turbojet, making the trade-off hovering times *versus* range more favourable than in the preceding example.

"Finally, a short-range, high-speed vehicle with relatively favourable hovering consumption, and in a size not much larger than an automobile, could be developed that is purely thrust-supported and saves all the weight and bulk, as well as some of the drag caused by wings. It is illustrated in Fig. 5. Here two small gas generators drive a ducted fan again by means of a rim turbine that produces the required lift and thrust forces. Its axis is set at an angle to the vertical, since the thrust vector produced must coincide with the resultant of weight and drag. This intriguing vehicle comes quite close to Dr. Lippisch's idea of an aerodyne."

Mr. Kappus thought that those four examples did not necessarily represent the best possible solutions to the various military and commercial requirements. He had selected them mainly to indicate possible variations. Reliability and early availability of powerplants, combined with low development costs, might be the most important considerations in the early phases of V.T.O.L. technology. But he went on to present a simplified analytical approach to illustrate the relative range capability of various V.T.O.L. propulsion systems. The main question was what specific engine weight, combined with which level of cruising fuel consumption, was required to make possible a desired range and payload capability. Another interesting aspect was the effect of hovering s.f.c. on range.

RANGE CAPABILITIES OF VARIOUS V.T.O.L. POWERPLANTS

Common assumptions: Gross weight, 10,000 lb; payload, 2,000 lb; t.o. thrust, 12,000 lb; total hovering time, 4 min.

Systems	Tilt-wing Turboprop	Fixed wing Turbojet Cluster Cascade Converter	Fixed wing Cruise Turbojet Converted into Fan for Hovering	No wing, Turbofan Thrust supported
Cruise speed (km/hr)	300	450	400	500
Cruise L/D or W/D ...	14	12	12	1
Cruise s.f.c.	0.7	1.15	1.2	0.25
Hovering s.f.c. ...	0.18	1.2	0.4	0.4
Airframe weight (lb)	3,000	2,800	2,800	1,800
Propulsion weight (lb)	2,400	1,500	1,400	1,200
Fuel weight (lb) ...	2,600	3,700	3,800	5,000
Hovering factor ...	0.986	0.908	0.968	0.968
Range (n.m.)	1,720	1,715	1,780	930

Attempting to suggest a very simple and, he hoped, useful method of illustrating the relationships involved, he stated that the well-known Bréguet formula could be modified for the V.T.O.L. trajectory. In the form in which it was presented, the Bréguet formula included the main powerplant characteristics of specific fuel consumption and engine specific weight. Assuming a certain speed and aircraft characteristics considered obtainable, the relationship of cruising s.f.c. and engine specific weight which were required to obtain a specified range could be plotted. For thrust-supported vehicles, a similar relationship, introducing the ratio of weight-to-drag in place of the aerodynamic L/D parameter, could be derived in analogy to the Bréguet formula. Mr. Kappus showed a graph of the relationship of cruising s.f.c. and specific engine weight to range for the assumptions noted. It was possible to plot in the same graph the relationship between s.f.c. and specific weight for a family of engines with different turbine inlet temperatures, pressure ratios or by-pass representing the possible state of the art in turbojets or turbo-fans. The most promising combination of engine weight and fuel consumption for maximum range and for the airframe characteristics and hovering time assumed could then be identified.

Using the simplified analytical approach outlined above, the lecturer said, the range obtainable with the four different V.T.O.L. engines discussed was calculated. To make the comparison simple, it had been assumed that all vehicles had a gross weight of 10,000lb and carried a load of 2,000lb. The cruising speed had been varied according to the capabilities of the respective power-

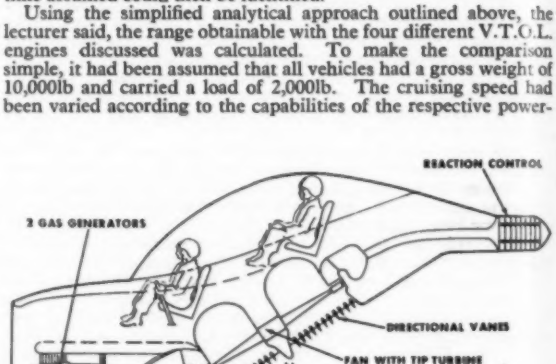


Fig. 5. Turbo-fan propulsion for a thrust-supported V.T.O.L. vehicle. Principle: Two lightweight gas generators driving a turbo-fan through a tip turbine which produces both lift and thrust. Application: Wingless, high-speed liaison and observation vehicles for moderate range.

plants. Aerodynamic and structural characteristics of the airframe and powerplant characteristics influencing the range had been considered in order to illustrate the use of the analytical method presented. The assumptions made and the total range obtained under these conditions were summarized by the lecturer in a table (left).

If the characteristics of actual V.T.O.L. aircraft and propulsion systems, continued Mr. Kappus, were as assumed in this table, the three winged aircraft investigated were quite competitive in range capability. The thrust-supported vehicle was somewhat down on range and especially in fuel economy, but its high speed, low bulk and simplicity nevertheless made it quite interesting.

The lecturer regretted that he had had time to touch only very lightly on the fascinating subject of powerplants. Many related problems appeared when similarly considering S.T.O.L. applications. Here the jet-wing [*sic*] principle posed very interesting problems to the powerplant designers. A relatively large number of small light-weight engines might provide an efficient solution.

In conclusion, the speaker stated that many of the V.T.O.L. powerplants mentioned would require considerable effort on the part of the engine manufacturer, both in developing the engine and, before that, in deciding, largely through analytical evaluations and design studies, which of the many possibilties should be developed. It was not practical to try out all of them. American research and development capacity was strained to the limit through the many complex high-priority projects aimed at supersonic and hypersonic, as well as at commercial, applications. Only the few most promising solutions would be followed in order to give the armed forces, commercial operators and, ultimately, the individual the "complete air mobility with all the revolutionary consequences which will be the result of the successful achievement of practical V.T.O.L."

CIVIL AVIATION

AIRPORTS AND THE TAXPAYER: A HARD-HITTING REPORT

A YEAR ago, in our issue of January 6, 1956, we reviewed an official report investigating the management of Britain's airports. "This report," we said at the time, "is a rather forbidding-looking document of nearly 300 closely printed pages, consisting largely of lengthy transcripts of verbal evidence. For this reason, perhaps, its findings have not been widely publicized in the national Press, though 'revelations' would not be too strong a word to apply to some of the facts disclosed."

The report just issued,* and which *has* been widely publicized in the national Press, contains the observations of the Treasury and the Minister of Transport and Civil Aviation on the recommendations of the first report. It reveals also that the losses incurred by Britain's State-owned airports, far from having diminished, have increased.

The actual operating loss has risen from about £1.67m to £1.86m—despite an 18 per cent increase in passenger traffic and a 39 per cent increase in freight. And taking into account non-operating expenditure—such as administrative costs away from airports, depreciation and capital interest—the *true* loss has risen from about £6m to about £7m. In effect this means that the average air traveller receives from the taxpayer an 8s subsidy on his airline ticket. This would be higher were not some airports privately or municipally owned (see below).

The report says that the increased losses make it "incomprehensible" that the Minister has not been prepared to take more energetic measures to increase revenue. Indeed, the report observes, it seems doubtful whether the Minister has taken "any measures at all to this end." The operation of the aerodromes is either "so inefficient or so financially insolvent that the more traffic there is, both passengers and freight, the greater the loss becomes."

The committee sees no reason "why air travel and the airways companies should be in such a favoured position compared to bus, railway, shipping and harbour companies and corporations." This state of affairs would probably not, we feel, be regarded as too disturbing if it was felt that practical steps were being taken to wipe out at least the operating losses.

Altogether seventeen recommendations were put forward in the original report. The principal ones are as follows:

Recommendation 4: "*A determined effort should now be made to produce trading accounts for the Ministry's aerodromes in a form acceptable to the committee of public accounts.*" The Ministry's comment upon this recommendation is that complex accounting problems would arise, but that this is a matter "which requires, and will be given, further (and detailed) study over a period."

Recommendation 6: "*Municipalities should be encouraged to own and operate their airports and to this end the Ministry should restate their policy on the municipal ownership of aerodromes . . .*" One of the Minister's comments on this is that he does not think the advantages of municipal operation would be sufficient to justify any drastic change, but he considers that "there is room for variety in the ownership and operation of aerodromes," with the parties concerned "all having a useful part to play."

Recommendation 8: "*The question of attracting increased traffic to the Ministry's aerodromes should be reviewed forthwith.*" The Minister's observation on this recommendation is that he is "in some doubt" as to what it means: traffic is increasing continually. The report's comment is that it is "surprising" that the Permanent Secretary of the Ministry of Transport and Civil Aviation has said in evidence: "We do not try to attract traffic . . . The object is not to make as much money as we can on the aerodromes, or even to make them pay."

Recommendation 9: "*In view of increased costs and the continuing loss on aerodromes in spite of increased traffic, landing fees should now be increased.*" The Minister observes that he has to take into account the possibility that such increases might tend to divert traffic from this country and might check the increase in traffic. A further review of policy will be made in light of the conclusions made at the end of the November 1956 I.C.A.O. Conference.

Recommendation 11: "*The passenger service charge should be reviewed with the object of (1) setting the basic rate higher . . . and (2) considering whether the charge should be levied on passengers landing rather than departing.*" Here again the Minister says that the proposal will be considered in the light of the I.C.A.O. meeting. [The I.C.A.O. conference urged the airlines "to make arrangements between themselves so that passengers will not have to make separate payments each time they land at an airport."—Ed.] The committee's point here is that "to continue virtually the same fees and charges as prevailed in 1948 . . . is not fair to the taxpayer who has to meet the losses through taxation . . ." and "to continue the present level of fees and charges is in fact subsidizing air travel . . ."

Recommendation 16: "*More urgent measures should be taken by the Minister to develop amenities and concessions at airports.*" The Minister's comment is that he welcomes any proposals from private enterprise for financing and developing amenities in a manner consistent with the efficient operation of the airport.

* * *

A sequel to the publication of the report was a statement issued by the private-enterprise operator of the British Aviation Services Group, which comprises the following independent airlines: Silver City, Britavia, Aquila, Lancashire Aircraft Corporation, Manx, Air Kruise. We reproduce the essence of this statement; it should be read in the light of the fact that 80 per cent of traffic movements in the U.K. are handled at Government-owned airports; nearly half the remaining 20 per cent is handled at Silver City's private airport at Ferryfield:—

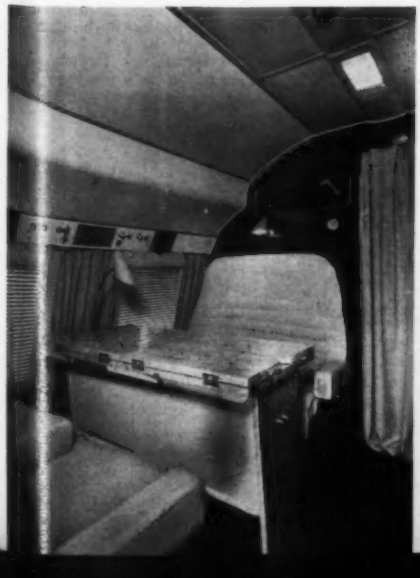
"In common with other independent airlines we are disturbed [said British Aviation Services] by the report's inference that we are being subsidized by the State, whereas in fact it is the State's own corporations which are being subsidized with taxpayers' money.

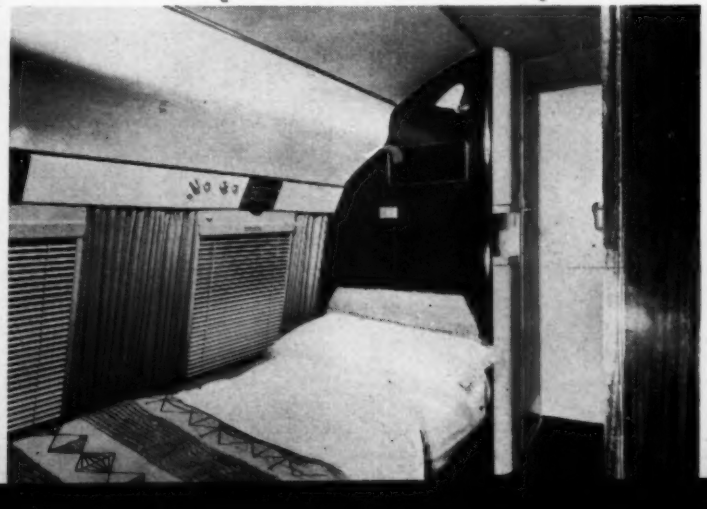
"Whereas the Corporations and other major international airlines use State airports almost exclusively, a very high proportion of independent airline operations are conducted from private and municipally-owned airports at no cost to the taxpayer.

"In fact it was the lack of adequate passenger facilities at one State airport which forced Silver City Airways, one of our group's subsidiaries, to build Ferryfield—the all-weather airport at Lydd, Kent. Despite the cost of this and similar projects undertaken by municipal authorities they and many other independent airlines have been able to reduce their fares.

"Schiphol Airport, Amsterdam, which ranks as one of Holland's main tourist and entertainment attractions, is a striking example of how an international airport can be made to attract revenue without imposing extra burdens on passengers or taxpayers."

* "*Special Report from the Select Committee on Estimates, Session 1956-57*" (*Civil Aerodromes and Ground Services*). *H.M. Stationery Office, price 1s 3d.*





Field Aircraft Services installed and furnished the writing-room and sleeping quarters of the special Viscount for the President of Brazil (see page 129). Fabrics, lighting and structural materials were studied and prepared with meticulous care.

CIVIL AVIATION . . .

IMPACT OF THE JETS—AT STOCKHOLM

SWEDEN has long been plagued by the problem of where to put the new international airport for Stockholm. Soon after the war it became clear that Bromma would become inadequate, and it was decided to build a new airport at Halmsjön, some 30 miles to the north. But the result was disappointing: the finished runway is of inferior quality and, because it is built over a hill and is bumpy, it has been declared unsuitable.

When S.A.S. ordered DC-8s the problem became pressing. Without good runways, Sweden would be unable to handle DC-8 traffic and Copenhagen's Kastrup would become the undisputed hub of all S.A.S. lines. But a committee, including Mr. Thorne-Holst of Scandinavian Airlines System and General Westring of the Swedish Air Force, has announced a plan to replace Bromma with a new airport 17 miles west of Stockholm at Skå-Edeby.

The new airport is planned to have an 8,000ft main runway ready in 1960 but it is intended that this would later be increased to 11,000ft: a second runway of 6,500ft is also planned. Subsequently, the main runway could be extended to 13,000ft. The cost of the Skå-Edeby scheme would be about £12.5m—£1.75m more than the cost of continuation at Halmsjön. The Skå-Edeby airport would have strategic advantages over Halmsjön, or to yet another scheme for an airport at Jordbro. Cost to S.A.S. of new administration buildings, technical facilities and maintenance hangars would be £9m.

—AT COPENHAGEN

KASTRUP Airport, Copenhagen, is soon to be considerably enlarged. It is to be rebuilt to accommodate "the largest types of jet airliners" (i.e. S.A.S.'s DC-8s, and the 707s and DC-8s of other operators into Scandinavia). The cost will be about Kr 180,000,000 (£9,350,000). It has recently been reported, incidentally, that Aeroflot wish to extend their Tu-104 services into Kastrup in order to connect with services into Denmark from the West.

New runways planned for Schiphol airport are shown in black; the existing runways are shown in full lines and possible extensions are dotted. The runway marked A is already in existence.

—AND AT SCHIPHOL

SINCE 1945, when reconstruction began on the ruins of Schiphol Airport, much planning has been done by the Amsterdam authorities to ensure that adequate runways would be available. To cater for the heavy runway lengths and passenger handling demands of the transatlantic jets the airport will be considerably increased in size. A drawing of the extensions appears below.

Around a quinquangular central area—opposite the present area on the edge of the Haarlemmermeer dyke—it is proposed to build four more or less tangential new runways and most of the present ones will go out of use. The new runway on the other side of the new terminal buildings will be a duplicate of the existing (01-19) runway. It will be identified as 01 left-19 right and the present runway will be 01 right-19 left. The aim has been to provide parallel runways which can be used simultaneously, one for take-off and the other for landing. On the far side of the new terminal area—the present terminal buildings will be expanded into a large technical centre—two other additional runways (12-30 and 03-21) have been planned.

The town council of Amsterdam have set aside six million guilders (£565,000) for runway 07-25, the first to be constructed. It will be 10,000ft long and should be completed in 1959. The length of the other new runways will vary from 7,500 to 9,000ft, but they can all be extended if necessary. This expansion at Schiphol will increase the area occupied from 1,730 acres to 3,330 and the total cost—including the new terminal building which will not be complete until 1963—will be about £30m.

THE ITALIAN MERGER

A NEW vice-president of the Italian airline L.A.I., Dr. Franco Palma, was elected at a meeting of the airline's council on January 12. He will succeed Sig. Richard Mazzarini, who will remain a member of the administrative council.

The meeting was also concerned with the formation of operational regulations when L.A.I.'s Viscounts are introduced on continental and Mediterranean services, and their L.1649As on flights between Italy and the U.S.A.

L.A.I. and Alitalia, the background to whose proposed merger appeared in *Flight* of January 11, have agreed to form a common board with the task of co-ordinating future action by the two companies, particularly with regard to the ordering of new aircraft. Opinion in Italy seems to be divided between support for a separate Minister for civil aviation and retention of the present system whereby the majority of ground and navigational services are operated by the Air Ministry.

OPERATOR FINED

THE pilot and owners of the Don Everall Rapide who were summonsed (see *Flight*, January 18) in connection with the accident near Elmdon were last week fined a total of £145.

The pilot, Mr. John Davies, was fined a total of £120 on five summonses: £30 for failing to ensure that there was sufficient fuel, £40 for incorrectly stating the payload; £30 for flying the aircraft at an excess weight; £10 for failing to comply with V.F.R.; and £10 for being in charge of a flight when he had not carried out a night landing and take-off within the previous 90 days.

The owners were fined £25 for operating an aircraft at a weight in excess of the maximum authorized, £2 for failing to produce duplicate copies of a load sheet, and £5 for failing to keep a record of the training of a pilot. A summons for operating an aircraft in a control area on a flight not complying with V.F.R. was dismissed, as was another for operating an aircraft at night the pilot of which had not carried out night take-offs and landings within 90 days.

The Prosecution stated that there was no criticism of the pilot's behaviour during and after the crash, but it was his duty to see that he had enough fuel; in a Rapide it could easily be checked visually.

On January 17, on its flight to Australia, Twin Pioneer G-AOEP visited Teheran and was demonstrated to the Shah of Iran (fourth from left). Scottish Aviation were represented by (left to right) Capt. J. Blair (co-pilot), Capt. Roy Smith (pilot) and D. F. McIntyre (managing director).

BREVITIES

ON January 21 Mr. Gerard d'Erlanger, chairman of B.O.A.C., left London to make a 30,000 mile tour of the Corporation's easterly routes upon which the Britannia will be operating later this year.

* * *

Mr. Leo Seybold of United Air Lines is to join the U.S. Air Transport Association as assistant to the president on February 15.

* * *

The three Twin Pioneers ordered by de Kroonduif will cost, together with spares, £233,645.

* * *

It is reported from Oslo that S.A.S. have been refused a renewal of their concession to call at Hong Kong.

* * *

Mr. G. E. Mustard has been appointed outside sales representative in London for Australian National Airways.

* * *

Derby Aviation has applied for a licence to operate three to seven services a week from Birmingham to Rotterdam.

* * *

Eagle Aviation are to start a "Spanish Eagle" air/coach service from London Airport to the Costa Brava. It will operate on a thrice-weekly basis from April 6 until the end of October.

* * *

Turkish Air Lines and Chicago Helicopter Airways have been admitted to the International Air Transport Association as active and associate members respectively.

* * *

Vice-presidents of the airlines flying the North Atlantic route will meet in London on February 4. They will "further clarify" decisions made at the I.A.T.A. Cannes traffic conference last summer for the introduction of "mass transport" fares on the North Atlantic route from April 1, 1958.

United Air Lines expect to employ an additional 228 pilots in 1957.

* * *

S.A.S. are to open a new ticket office and town terminal in Glasgow. The telephone number will be City 5832.

* * *

On June 1 Britavia is to start a once-weekly flying-boat service between Southampton and Montreux, Switzerland.

* * *

Sabena will lease three DC-7Cs under long-term contract from the International Aircraft Leasing Company. The company is to buy the aircraft from Douglas for £2,550,000.

* * *

Mr. Ben Schoeman, the South African Minister of Transport, said in Johannesburg on January 16 that South Africa was about to introduce a new service to London *via* Leopoldville. Night stops might be made at Kano or Tripoli.

* * *

The Guild of Air Pilots and Air Navigators is assisting three pilots to obtain their commercial licence and instrument rating. The Guild will ensure that employment will be obtainable for these men when they are qualified.

* * *

Commenting upon reports that a South Atlantic service pool was to be formed by Lufthansa, Air France, and Aerolineas Argentinas, Lufthansa say that they are primarily interested in reviving their pre-war arrangements with Air France.

* * *

An air traffic agreement—as yet unsigned—has been drawn up between Switzerland and Scandinavia. It provides for Swissair flights to Stockholm beginning on April 14 and for S.A.S. flights to South America, the Near East and Far East, to be routed *via* Switzerland.

R.Ae.C. ENTERTAINS AIR-RACE WINNERS

THE 1956 British Air Racing Champion, F/L. H. B. Iles, and the winner of the 1956 King's Cup Air Race, Mr. J. H. Denyer, were the guests of honour at a dinner given by the Royal Aero Club on January 22. Speaking of this year's planned air-racing programme on this occasion, the Club's secretary-general disclosed that a decision would be made in April as to whether, in view of the fuel situation, the races should be held as planned. If fuel supplies were not better in April than at present, he said, the races would probably not take place.

After Col. Preston had introduced the two guests of honour, Mr. S. Kenneth Davies, R.Ae.C. chairman, had some comments to make on private flying in general. The dinner came at a crucial point in private-flying and racing affairs, he said. Both pilots being honoured were relative newcomers to racing, and their success was a healthy sign at a time when "we are struggling to keep private flying alive."

Referring to restrictions on private flying, Mr. Davies said, "We are going to make a fight. We have kept quiet long enough." As an example of these restrictions, the speaker referred to the construction of television masts close to the approaches to Cardiff Airport. When he had objected to the erection of the second mast, he discovered that he was arguing with the Ministry of Transport and Civil Aviation, whose reply had included the statement: "It is no worse than landing at Gibraltar."

After paying a tribute to G/C. du Boulay, who had been very active in the air-racing field before recently leaving the Club, Mr. Davies concluded by congratulating Mr. Denyer on his King's Cup success and presenting F/L. Iles with the Air Racing Championship Trophy.

Jim Denyer's reply was interrupted at the start by a rather shaky rendering of "Hearts and Flowers" by Beverley Snook on the violin. The speaker went on to deny that his winning the King's Cup was a fiddle, and concluded by paying a tribute to the racing "back-room boys" of the Royal Aero Club.

F/L. Brian Iles also thanked the Club, and also the companies who generously supported the race meetings. Three things were needed for success, he pointed out; an obscure aeroplane, a thoroughly filthy aeroplane, and an innocent face. These would all help to fool the handicappers; clearly Bev Snook could never succeed on the third count.

Mr. S. Kenneth Davies (centre, top photograph), speaking to Jim Denyer (left) at the dinner, with F/L. Iles on the right. Lower photograph, Messrs. A. Irwin, Beverley Snook (minus violin), Denyer, C. Gregory and J. R. Johnston.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

Bells of St. Clement's

ON Thursday last week the recast bells of St. Clement Danes, which is to be the church of the R.A.F., were dedicated and named. The dedication service was conducted by the Chaplain-in-Chief of the R.A.F., Canon A. S. Giles; and Air Chief Marshal Sir Dermot Boyle, Chief of the Air Staff, named the great tenor bell "Boom" in memory of Lord Trenchard. Inside each bell is a Latin inscription and that in "Boom" translates as "Once from the heavens came ruin, today in the heavens there is a peal of joy."

The other ten bells were named by representatives of the Civil Service, and by contributors to and participants in the restoration work. The scaffolding and the old sanctus bell were decorated with oranges and lemons and greenery provided by Miss Dinah Wilson, for 70 years a flower girl opposite St. Clement Danes, which is traditionally the flower girls' church. Fruit was distributed by Canon Giles and Sir Dermot Boyle to 20 children from St. Clement Danes School.

The bells are now being mounted in the belfry, and being one more in number than before the church was destroyed during World War 2, they can now correctly sound the traditional "Oranges and Lemons" tune—and also the first bars of the R.A.F. march. At the end of last week's ceremony, Mr. A. A. Hughes, chief caster of the Whitechapel bell foundry, played the nursery rhyme tune on the bells as they stood upended where they had been named.

Christmas Island Canberras

TEN R.A.F. Canberras are undergoing flying tests in South Australia in preparation for the British hydrogen-bomb trials due to be held later this year at Christmas Island in the central Pacific. They have been fitted with special instruments and apparatus for recording details of blast effect. Six of the aircraft are to be sent to the forward area, near Christmas Island, and four are being kept in reserve.

Air Chief Marshal Sir Dermot Boyle, Chief of the Air Staff, naming the great tenor bell of St. Clement Danes, the church of the R.A.F. He called it "Boom" in memory of Lord Trenchard.

All-through Jet Training

ELEVEN pilots of No. 113 Course at R.A.F. Swinderby have now passed out after training entirely in jet aircraft. Speaking at their passing-out parade last week, A.V-M. H. R. Graham, A.O.C. No. 23 Group, Flying Training Command, congratulated them on having "done extraordinarily well." He said he hoped that before he finished his term as A.O.C., the majority of student pilots would be trained entirely on jets. It was a simpler system and put students in the right frame of mind at the outset. It also reduced the training period.

Air Commodore Postings

IT is announced that G/C. J. D. Melvin is to be Director of Organization at Air Ministry after completing the 1956 course at the Imperial Defence College. G/C. E. L. Colbeck-Welch is to become Commandant of the Central Fighter Establishment at West Raynham. Both will have the acting rank of air commodore.

A. Cdre. W. P. Sutcliffe, who has recently been on intelligence duties with S.H.A.P.E., has been appointed Director of Operational Training at Air Ministry. G/C. J. N. Tomes has been appointed for duty with the Defence Research Policy Committee, receiving the acting rank of air commodore.

G/C. P. D. Holder has been appointed A.O.C. Singapore with the acting rank of air commodore. G/C. B. J. R. Roberts, who also receives the acting rank of air commodore, has been appointed Senior Air Liaison Officer and Air Adviser to the High Commissioner in Canada and will take charge of the United Kingdom Service Liaison Staff (Air) at Ottawa next March.

Kenley's New Bar

AT a party in the Officers' Mess at R.A.F. Kenley last week, a new and larger bar was opened. The central feature of its décor, which commemorates the station's part in the Battle of Britain, is a painting of a Spitfire in action by David Shepherd. This has been bought by mess members and was presented during the party by A.V-M. J. M. Cohu, A.O.C. No. 61 Group, whose headquarters are at Kenley. Other new decorations include many sketches made during the battle and the badges of squadrons based at Kenley. Among the guests were Air Marshal Sir Richard Atcherley, who commanded Kenley in 1940, and Group Captains Johnson, Bader, Dundas and Kent.

Sylt Helicopters

DURING last year the crews of the Helicopter Air/Sea Rescue Flight on the island of Sylt, Germany, made no less than 758 sorties. The last operation of 1956 was the lowering of six men during a freeze-up to two stranded R.A.F. rescue launches, so that these could be returned to harbour as soon as the ice cracked. Other sorties covered the rescue of R.A.F. and Allied airmen from land and sea, casualty evacuations from ice-bound islands, going out to ships in distress, saving swimmers and reporting live mines off Sylt's holiday beaches. The Flight was formed in 1954.

Reunion

THE sixth annual reunion dinner of No. 609 (West Riding) Squadron is due to be held at the Guildford Hotel, Leeds, on February 9. Eight wartime Belgian pilots are expected to attend the dinner. Details from Frank Ziegler, Esq., D.F.C., New Place, Haslemere, Surrey.

Poise, personality and impeccable business suiting distinguish pilots of No. 898 Sqn., F.A.A., as they receive a final briefing from their C.O., Lt-Cdr. D. B. Morison, before setting off from Brawdy to take up residence in "Ark Royal."

Staverton Resettlement

Problems of "Civilianizing" a Wartime Airfield

A general view of the airfield, showing the three war-time runways and part of the industrial estate.

LIKE young men who gained a new status and rank in war, and afterwards found it difficult to fit themselves into the post-war world, some airfields acquired runways and facilities during 1939-45 which their present owners are now endeavouring to put to the best economic use.

A case in point is Staverton in Gloucestershire (pronounced locally not with lazy, well-bred long "a" but the rich, local short "a"). In the Vale of Gloucester, midway between the busy but dissimilar centres of Gloucester and Cheltenham, and cradled by the gentle Cotswolds, Staverton Airport is controlled by a joint committee of the two corporations, whose aim is to have the runways, buildings and industrial estate in as full employment as possible, for the benefit of the 132,610 people who live in the cathedral city and the spa, and the thousands more dwelling in the countryside round about (there is a population of 200,000 within ten miles' radius of the aerodrome).

Before the war, Staverton, under the same ownership, was a modest grass airfield suitable mainly for light aircraft. Early in the war, the Ministry of Works, at the instigation of the Air Ministry, put down three runways, N-S (3,060ft), NE-SW (3,240ft) and E-W (3,000ft). During the war R.A.F. navigators, many of them Canadians who had come over under the Empire Air Training Scheme, were trained at No. 6 Air Observer Navigational School at Staverton. Hangars were built and an industrial estate was established. Thus, when Staverton was no longer needed as a sword, Gloucester and Cheltenham were left with a well-equipped ploughshare which now pays its way but which they are determined to expand and improve.

A recent first visit to Staverton left one with the impression that with such amenities at their disposal the two municipalities are batting on a good wicket and that they deserve success. In the first place, the aerodrome is well situated, right on the A.40 road from London to Fishguard, and only 4½ miles from both Gloucester and Cheltenham. Secondly, its three runways, though not long by present-day standards, are perfectly adequate for feeder-line and short-range commercial aircraft. (That they can, in fact, be successfully used by modern jet aircraft was shown in 1954, when two Canberras, on their way to Moreton Valence, landed there by mistake and then took off again for their right destination.) To improve the length available, an extension of the east-west runway by over a thousand feet to 4,120ft is now being considered. In addition, Staverton is available for use at night at any time. Thirdly, the flourishing industrial estate—which in fact subsidizes the flying activities—has room for several more tenants. Fourthly, being in the middle of a "green belt" area, the site is not likely to be killed off by urban encroachment. Lastly, the upkeep costs of the airfield in terms of staff are comparatively small, an estate officer with five people under him being the total regularly employed.

Mr. E. Jones, one of the traffic controllers, on duty in the control tower of the recently constructed terminal building.

While Staverton is well situated in the sense of being accessible, it suffers somewhat from its comparative proximity to Bristol, and at present the Heron and Dove schedules operated by Cambrian Airways, Ltd., from Staverton all fly *via* Bristol on their way to their destinations (Paris, Channel Islands and elsewhere). If flights could be made direct, that to the Channel Islands, for example, would be reduced from two hours to 1½ hours or 1 hr 20 min.

The airport committee wants a longer runway (as already mentioned); it also wants Customs facilities, so that flights can be made direct to or from the Continent, instead of having to go either through Bristol or Southampton; and it wants (and is hoping to acquire in the reasonably near future) an approach aid.

Airfield control is at present kept reasonably busy in winter and very busy in the summer. Of course, the latter picture is the one the municipalities would like to see all the year round, with regular schedules coming and going direct to the Continent and to British cities like Manchester, Birmingham, Liverpool, Cardiff, Glasgow, Belfast and Southampton, in addition to the test and club flying already carried out at Staverton. At present most of the traffic occurs in the holiday months, from Easter until September; already over 200 bookings have been received for this year's flights, and last year Staverton handled 2,000 passengers—an increase of 200 on the total for 1955.

The airport manager, Mr. S. G. Smith, ex-R.A.F. Coastal Command and a qualified air traffic control officer, is employed by Cambrian Airways, and his responsibilities include not only their aircraft (Herons, Doves, sometimes a Dakota or a Rapide), but all the types used at the aerodrome for test and pleasure flying.

Both the latter varieties of flying justify Staverton's claim to be the centre of Gloucestershire aviation, for there are three flying clubs on the aerodrome and test flying is carried out by Smiths Aircraft Instruments, Ltd.; and to have airline, private and industrial aviation within the same boundary is more than any other Gloucestershire airfield can boast. The clubs are the Cheltenham Aero Club (which has an Autocrat, Aiglet and Miles Messenger); the Cotswold Aero Club (employing an Auster, a Miles Monarch and a Tiger Moth); and the Rotol Flying Club, who use solely an Auster. For their test flying Smiths Instruments employ a Dakota and an Anson, whilst a Proctor is used for business journeys.

Smiths, with their main factory at Bishop's Cleeve, north of Cheltenham, do not have premises on the Staverton industrial estate; those who do are Rotol, Ltd., the oldest and largest inhabitants, their associated company British Messier, Ltd., and eight other firms. The other tenants of the industrial estate are that part of the Dowty Group located at Staverton, with an engine test site there; Wynstruments, Ltd.; Granville Sheet Metal Works, Ltd.; Cheltenham Patternmaking; Thos. Parsons and Sons, Ltd.; Watney, Combe, Reid and Co., Ltd.; Bryco (Building Products), Ltd.; Kingscote and Stephens (Caravans). Mr. R. F. Darby, the aerodrome estate officer, would naturally like to have more tenants; and certainly with a total of 75 acres, of which only 38 are at present in use, there is plenty of room still available.

[*Contd. overleaf*

STAVERTON RESETTLEMENT . . .

Staverton, so centrally situated for Gloucester and Cheltenham, is more than an aerodrome for the people of those centres and the surrounding countryside. For over 7,000 of them it means employment; for 2,000 last year (and probably more this) it means a gateway to the Continent by a means of travel which gives them an extra day's holiday because of its swiftness compared with boat and train; and for many more—if plans for increasing the size of the industrial estate are fruitful—it may mean a livelihood. This aspect of Staverton development may become especially important, economically, to the area if contracts for the Javelin—which now keep busy several thousand people at the Gloster Aircraft Co., Ltd., and at Armstrong Siddeley (Brockworth), Ltd.—should come to an end. For all these reasons, the corporations of Gloucester and Cheltenham deserve success in their plans and hopes for the expansion of Staverton. H. W.

". . . Rotol, Ltd., the oldest and largest inhabitants . . ."

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

Chipmunk Airworthiness

WITH reference to the recent interchange of correspondence in *Flight* relative to obtaining Certificates of Airworthiness for ex-Service Chipmunk aircraft, it may be of interest to those concerned to know that this company, in association with Flight Servicing and the College of Aeronautics, has now been responsible for the civil certification of sixteen of these aircraft. This total includes the initial prototype which was purchased from the Air Ministry in April of last year, and was the first Chipmunk Mk 22 to be awarded a C. of A. in the following month.

This conversion programme continues without hindrance and demonstrates that no insurmountable difficulties have been encountered other than delays normally associated with the incorporation of modifications to an aircraft, either ex-Service or civil, which has spent a considerable time in storage.

We should like to take this opportunity, therefore, of expressing our thanks to the de Havilland Aircraft Co., to the makers of the various accessories, and particularly to the Air Registration Board, for their co-operative attitude and willingness to discuss operational details (such as the spinning regulations) for inclusion in the Flight Manual.

Particularly, we should like to feel that the initial development of this fine training aircraft will be of assistance to all subsequent operators, both at home and overseas.

Croydon Airport, Surrey. L. W. WENMAN,
Manager, Airways Aero Associations, Ltd.

[Airways Aero Associations, Ltd., are proprietors of the Airways Aero Club at Croydon.]

Remaining Rarities

IN his article on "Remaining Rarities" (*Flight*, January 4) Mr. David E. Ogilvy writes that the Beaufighter has not operated in this country for the last three years.

But certainly one Beaufighter was flying over this country on many occasions last year. I have seen it flying, roughly east and west, over Sully Hospital on the Glamorganshire coast. It was painted yellow and a dark colour in bold diagonal stripes and it appeared equipped for target towing.

Penarth, Glam. HUGH MORONEY.

REGARDING the article in *Flight* on "Remaining Rarities," I think it might interest Mr. Ogilvy to know that I saw a Beaufighter over here on December 31, 1956.

Rothbury, Northumberland. B. REID.

Soviet Contrails?

REFERRING to the article "Identification by Contrails" in the August 3, 1956, issue of *Flight* I enclose a picture I took from the roof of our house sometime in September. [Our correspondent's photograph, unfortunately, is not suitable for reproduction; the contrails are too distant and faint—Ed.]

The town of Hangö, being the southernmost in Finland, lies on the "doorstep" between the Gulf of Finland and the Baltic Sea, less than 50 miles from the Estonian coast. The picture was taken at 2 p.m., a very clear day, with the camera aimed towards the south-east. These contrails—which, by the way, are quite familiar to us in Southern Finland, as they are visible on most clear days—are not made by aeroplanes of the Finnish Air Force, according to statements in the press. This is likely to be true, as the few jets we have (Vampires) are very rarely seen in this area.

Thus I, and others, too, have come to the conclusion that they are made by aircraft from behind the so-called Iron Curtain. On this particular day I studied the contrails very carefully through a pair of strong (8 × 60) binoculars and for the first time I managed to get the aircraft themselves in sight. They made long sweeps from east to west and back and at first I thought that they were all single-engined. But when the machine that made the two uppermost trails on its eastward run turned towards the south-east (where it was crossing some of the other contrails) it gave me the opportunity to see it from behind, and I noticed that there were two very sharply pointed streams close together. These two trails soon joined into a thicker trail with a thin dark band in its middle.

I thought that the twin-engined aircraft I was observing might fall within that possible 5th group in that *Flight* article. I also think I might have witnessed a training or mock attack between the twin-engined and two single-engined aeroplanes. The only details I could detect apart from the contrails were that the single-engine machines sent out bright and gleaming sun reflections and that the twin seemed dark and matt.

Hangö, Finland. FINNISH READER.

"Sensitive" Industry

OF recent years the British aircraft industry has become, in my opinion, unduly sensitive to criticism. I would be the last to advocate "knocking" an industry, particularly when that industry was not in an entirely happy position. Nevertheless, when men in eminent positions produce what are to my mind wholly specious arguments in defence of such an industry, I feel that attention should be drawn to the fact.

The classic case in recent months is the storm which centred around the paper delivered before the Royal Aeronautical Society by A. Cdre. F. R. Banks. Noted as a forthright speaker, Mr. Banks elected to cast doubt on our ability as an aircraft-producing nation. As far as I can determine, his arguments and criticisms were entirely constructive, and I have yet to see any of them refuted. Nevertheless, a hubbub of dismay arose, centred almost entirely on his single (and perhaps unfortunate) assertion that "In quality of equipment the R.A.F. is about fourth after the U.S.A., Russia and Sweden." The most curious arguments have been used to support the contention that this is not so. Perhaps the lecturer was, on this one point, unjustified; in any case the subject is too general for discussion to be worth while. My point in citing the case is that nobody bothered—or perhaps nobody was able—to challenge the remainder of the paper, which was long, informative and, to an Englishman, profoundly disturbing.

Now I find Sir Arnold Hall, one of our very finest aeronautical scientists—I hope he will not take exception to being so described—perpetuating this most fallacious of all arguments, that a nation which can export three hundred million dollars' worth of aviation products a year must be "all right."

If one examines this export success one cannot fail to notice that the bulk of the business has been gained by one aeroplane, the Viscount. I cannot refrain from quoting Mr. Peter Masefield, who once said: "The confirmation of the Elizabethan order by B.E.A. marked the lowest point in the fortunes of the Viscount. *At this time it seemed that the project was doomed*" (my italics). It seems that, but for the courage of the original Pierson-Edwards team at Vickers, we just would not have had a Viscount at all. That Sir Arnold has his $300m is therefore wholly fortuitous.

To approach the argument from another angle, it is of fundamental importance to remember that nearly all the aircraft which

CORRESPONDENCE . . .

make up our export business are based on techniques which have been fully understood for many years, and which were within the (limited) capacity of our industry to develop. Admittedly the Comet, Viscount and Britannia have something quite new in the way of airline powerplants (achieved by very considerable public expenditure on civil engines, a new doctrine), but none of our export machines involves aerodynamic, structural or engineering research on the scale needed for supersonic aircraft. I do not believe that our industry could have achieved success with such machines as the DC-8 or the "century-series" fighters—at least, not within a time-scale calculated to give an even chance of commercial success.

All that the "three hundred million dollar argument" tells us is that, provided we stick to what we can cope with, we can make aeroplanes which are at least as good as those of any other country, within a competitive time scale and for a competitive price. (A vital contributing factor is that certain of our companies enjoy the respect and trust of their customers; selling aeroplanes is a business in which success hinges largely on past performance.)

But the fact that one aspect of our industry is at present healthy is no answer to a critic who argues that another aspect is ailing. And we are very definitely ailing in many of the most vital departments. We have very few supersonic aeroplanes (two F.D.2s and two P-1s, to be precise); we have grossly underestimated the effort required to develop guided weapons; we have little experience of big rocket motors—no doubt owing to the absence of anything to put them in; our expenditure on research equipment has been pitifully small, by any standard; and, to quote Mr. W. E. W. Petter, we are still spreading our available resources too thinly, with "too many channels for too little water."

These facts are not repeated here for spite; they are most unpalatable. But they are too often glossed over with three-hundred-million-dollar arguments in a manner which creates despair among all true friends of our industry. There is no need to feel ashamed of our record. We should not need to make excuses and no country is perfect. Sir Arnold points out that we had to build houses to replace those destroyed in World War 2, thus diverting effort from, *inter alia*, aeroplanes. How, then, does he explain the fact that Russia, almost entirely shattered by the largest armies the world has yet seen, has nevertheless been able to rise from aeronautical mediocrity to a position which may well earn her the title of the world's premier air power? As far as I am aware, Russia has enjoyed nothing that has been denied to us; and it is certain that she was technologically several years behind us in 1945. (I have yet, incidentally, to meet the man who would claim that 100,000 men could produce an efficient and usable new aircraft design more quickly than could 1,000.)

As far as I am concerned there must be a lot of honest thought applied to our overall aeronautical scene. Half the picture—which can broadly be lumped under the headings of "simple aeroplanes" and "engines"—is bright and prosperous. The other half—the part which gives us our weapons and export products of a decade hence—appears to be giving a poor return for the severely limited expenditure which we can afford, and to be the cause of a wholly unreasonable number of personal white hairs and ulcers. Until we can embark on the design of an advanced transport or weapon system with certainty of success and certainty of on-time delivery, I feel it is inappropriate that we should crow over the fine achievements of what might be termed the "easy" half of the industry.

London, W.1. TECHNICIAN.

Misplaced Hangars

YOUR excellent magazine contains a small error in the report (page 62, January 11) on the closing of the Royal Air Force staging post at Mauripur.

The statement that airship hangars are still standing at this base is incorrect. I myself spent two years in the Movements Section at Mauripur and I assure you that the hangars in question are on the boundaries of the present International Airport. I believe they are at present used as a store. The distance between Mauripur and Karachi civil is nearly twelve miles, and they are on opposite sides of the city.

London, S.W.17. M. J. PEARSON.

[We thank our correspondent for the correction; the original information was from an official source—Ed.]

ONE MORE FOR THE FARMER

NOW undergoing certification flight trials in the U.S.A. is the Snow S-2 agricultural aircraft, a low-wing monoplane powered by a 220 h.p. Continental engine. It is the production version of the S-1 prototype, designed and built by Leland Snow, which first flew in 1953. First flight of the S-2 took place in August 1956.

The wing section used on both machines, a highly cambered aerofoil with considerable droop at the trailing edge, was chosen to give the maximum downwash and turbulence. With the spreader outlet located only six inches below the wing trailing edge, the S-1's swath was found to be formed "almost immediately behind the aircraft, rather than several hundred feet to the rear."

Further details of the S-1 and S-2 aircraft, as given by the designer, are as follows:

"The control system in both the S-1 and S-2 is frictionless and all surfaces are aerodynamically balanced to reduce pilot fatigue. The amount of longitudinal stability incorporated was enough to give the pilot sufficient feel but not enough to create heavy stick-loads in pull-ups. The lateral stability of the S-1 was a little more than necessary so 1½ deg less dihedral was used in the S-2.

"The first consideration in the design of the two aircraft was that of pilot safety. Unequalled pilot visibility in all directions will go a long way toward eliminating collisions with wire, trees, standpipes and other airplanes. The high overall performance and wing-section used make the airplane virtually stall-proof. The light stick-loads reduce pilot fatigue and keep him more alert. The low operating speed and high manœuvrability allow a greater margin of error in judging pull-ups over obstacles. The hopper location (behind the cockpit) protects the pilot from toxic materials. Wire-cutters are installed on the landing gear and a steel cable protects the rudder and fin.

"If the pilot goes ahead and gets into trouble anyway, he's got a steel-tube structure stronger than either a Stearman or BT-13 structure to keep the cockpit section intact. The longerons are 1½in chrome-moly tubing. For fire prevention the S-2 utilizes an all-metal construction with gas tanks in wings, and has no electrical system. The seat is mounted so as to place the pilot above the bulk of the load. A 20g overturn structure is located inside the headrest.

"The S-2 fuselage is constructed of welded steel tubing covered with a removable metal skin. All steel structures are metalized with zinc to eliminate corrosion, and all dural parts are alodized and chromated. The airframe is stressed for a Pratt and Whitney engine.

"The hopper is within easy reach of a loader on the ground, has no baffles or braces to interfere with loading, has a 36 cu ft (1,500 lb) capacity, and a 36in × 33in loading door. Conversion from dusting to spraying (180 gal tank) can be made by two men in five minutes.

"Specifications and performance data include the following: span, 38ft; wing area, 285 sq ft; empty weight, 1,943 lb; design gross weight, 3,600 lb; stalling speed (empty), 35 m.p.h., (at gross weight), 49 m.p.h.; cruising speed (empty), 100 m.p.h., (at gross weight), 90 m.p.h."

FORTHCOMING EVENTS

Feb. 2. British Interplanetary Society: "Accelerations in Flight," by W/C. F. Latham.
Feb. 5. Aviation Forum: "Catering on Aircraft" by W. Michel.
Feb. 6. Kronfeld Club: "Dis-orientation in the Air," by Dr. G. M. Jones.
Feb. 7. R.Ae.S.: Main Lecture, at Halton, "Synthetic Training Methods in Aviation," by W. Makinson.
Feb. 11. Institute of Transport: Brancker Memorial Lecture: "Competitive Economics of Pure-jet v. Turboprop Aircraft," by Marshal of the Royal Air Force Lord Douglas of Kirtleside, G.C.B., M.C., D.F.C., M.Inst.T.
Feb. 12. Joint R.Ae.S. and Helicopter Association Lecture: "Vibration Problems Associated with the Helicopter," by O. L. L. Fitzwilliams, A.F.R.Ae.S.
Feb. 13. R.Ae.S.: Graduates and Students Section: "The Area Rule," by W. T. Lord.
Feb. 13. Kronfeld Club: Czechoslovakian films.
Feb. 14. R.Ae.S.: Main Lecture: "The Fairey Delta," by R. L. Lickley and P. Twiss.
Feb. 15. Institute of Navigation: "Navigation and Traffic Control Over the North Atlantic," by D. O. Fraser.
Feb. 16. British Interplanetary Society: Chemical Demonstration by Dr. J. Diederichsen.
Feb. 26. R.Ae.S.: Section Lecture: "Recent Advances in the Design of Aircraft Tyres and Brakes," by H. W. Trevaskis, A.F.R.Ae.S.
Mar. 7. R.Ae.S.: Tenth Louis Blériot Lecture: "New Methods in Aircraft Production," by M. Badré, production director of Sud Aviation.
May 24-June 2. Paris Aero Show, Le Bourget.
Sept. 2-8. S.B.A.C. Show, Farnborough.

R.Ae.S. Branch Fixtures (to Feb. 15)

Feb. 5, *Boscombe Down*, "Human Limitations of High Performance Flight," by G/C. W. K. Stewart. Feb. 6, *Luton*, "Production of Light Alloy Forgings," by J. Crowther. Feb. 13, *Leicester*, "Flight Development of Modern Prototype Aircraft," by C. F. Bethwaite. Feb. 15, *Brough*, Annual Dinner and Dance.

Members of the Hawker Siddeley design council visited the Avro factory at Chadderton last week. Included in this picture are Sir Thomas Sopwith (seated, in the centre of the picture), group chairman, and on his immediate right (seated) Sir Roy Dobson, Avro managing director, and Sir William Farren, Avro technical director. On Sir Thomas's immediate left (seated) are Sir Frank Spriggs, group managing director, Sir Arnold Hall, group technical director, and Sir Sydney Camm, director and chief designer, Hawker Aircraft.

THE INDUSTRY

Thermo-Plastics' Quarter-Century

ON January 16 the 25th anniversary of Thermo-Plastics, Ltd., was celebrated, and in a historical note the company records that during the war years it was wholly engaged on work for the aircraft industry, and that now approximately 30 per cent of its output is for aviation applications.

In 1932, however, the company's work was confined to the manufacture of facia letters, signs and display items, and it concentrated on the use of the sheet plastic material then in existence, cellulose acetate; but within a few years the production of components for aircraft began.

During the war, with new materials such as Perspex and wire-reinforced acetate becoming available, this side of production inereased tremendously in importance and among components manufactured were aircraft canopies, air chutes, radomes—in which the firm specializes—and air ducts. War-time work on radome equipment led to Thermo-Plastics becoming one of the pioneers in the production of components from glass-reinforced materials.

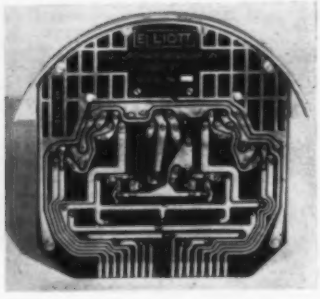
In 1941, Plastra Components, Ltd. (one of two associated companies), was acquired and in 1947 a permanent factory was built at Dunstable, where temporary premises had been occupied since 1939.

Compact Radar Receiver

ILLUSTRATED below is a sub-miniature radar receiver—the compact design of which is largely due to the maximum use of printed-circuit techniques—introduced recently by Elliott Brothers (London), Ltd., Borehamwood, Herts.

The receiver comprises six replaceable plug-in units, five of them made with all components on one side of a Bakelite copper-clad laminated sheet, the etched circuit (including gold-plated etched plugs) being arranged on the opposite side to allow connections to be made by dip soldering. Where valve wires are to be connected, small eyelets have been inserted into the board, so that if a valve change is necessary at a later date, no damage can be caused to the copper foil due to careless hand soldering.

One of the receiver's main features is the use of printed-circuit sheet connections at the rear of the sockets, demonstrating that dip soldering or automatic soldering techniques can be applied as readily to these inter-connecting points as to the individual replaceable units. Throughout the receiver, indeed, almost all wired joints have been eliminated.



On the left is a complete sub-miniature radar receiver by Elliott Brothers. Five of the six plug-in units are based on printed circuits made from Bakelite copper-clad laminated material; one such unit is shown below.

Bristol Aero-Engines Appointment

THE appointment of Mr. Basil Blackwell as assistant chief engineer of Bristol Aero-engines, Ltd., was briefly announced in a late news item (p. 96) last week, and it is now possible to give further details. Mr. Blackwell joined the engine division of the Bristol Aeroplane Co. (now Bristol Aero-engines, Ltd.) in 1949, having previously been with Rolls-Royce, Ltd., and—from 1942 to 1945—with the Directorate of Scientific Research at the Admiralty. At Bristol, he was first responsible for the aerodynamic design and development of turbines on all Bristol engines; then he became a member of the project team which designed the Olympus 6, Orpheus and Orion, and in 1955 he initiated a new blade engineering department for research, design and liaison work on compressor and turbine blading. This department, of which he has been in charge until now, will continue to be one of Mr. Blackwell's responsibilities. He will be directly responsible to the chief engineer, Dr. S. G. Hooker, and will represent him in certain special activities.

Mr. B. Blackwell.

IN BRIEF

A recent development in the forging side of the work of Hadfields, Ltd., East Hecla Works, Sheffield 9, has been the manufacture of aircraft forgings in certain of the Nimonic alloys.

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Mr. C. M. L. Walker has been appointed sales consultant in the Midlands for Ferranti, Ltd. Formerly area manager, he has been succeeded in that position by Mr. R. S. Winter.

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Mr. John Drummond, who has edited *Shell Aviation News* for the past ten years, moved over last month to a marketing appointment in the aviation department of the Shell Petroleum Co., Ltd. He is succeeded as editor by Mr. Brian Haimes.

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From Montreal comes news that Sandford Bruce Fleming has rejoined the flight operations department of Canadair and is to test Sabre 6s, T-33s and CL-28s. Mr. Fleming originally joined Canadair in 1949; in the interim he has served for a second time with the R.C.A.F.

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An exclusive manufacturing and sales agreement for Metalastik products with Carl Freudenberg, Weinheim, Germany, has been announced by the chairman and managing director of Metalastik, Ltd., Mr. M. Goldsmith. Metalastik, Ltd., with Precision Rubbers, Ltd., are members of the John Bull group, Leicester.

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At the annual apprentice prize-giving of George Kent, Ltd., Luton, Beds, on January 7, so many apprentices qualified for the attendance prize that they had to assemble in two ranks in front of the dais to receive their awards. Cdr. P. W. Kent, R.N. (Retd.), chairman and managing director, presented the prizes and Sir John Burgoyne, O.B.E., J.P., was guest speaker.

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Two new sales appointments have been announced by the Chloride group of companies. Mr. T. Dawson has taken up the new post of group export sales manager and he will also be responsible for commercial liaison with the group's associate companies overseas. Mr. P. C. Aspinall, who was assistant export manager under Mr. Dawson, becomes the new export manager for Chloride Batteries, Ltd.